

Santa Ana River/Mentone Fan Hydrological Study

Prepared for
Mary Meyer, Plant Ecologist
Department of Fish and Game
Inland Deserts-Eastern Sierra Region
Conservation Planning Division
330 Golden Shore Suite 50
Long Beach, California 90802

Funded by
United States Fish and Wildlife Service Section 6 Funds
Contract Number FG7640R5

Prepared by
Howard H. Chang, Professor
Department of Civil and Environmental Engineering
San Diego State University
March 1999

	TABLE OF CONTENTS	PAGE
I. INTRODUCTION	1	
II. PHYSICAL DATA OF SANTA ANA RIVER	2	
Hydrological Data	2	
Floods of Santa Ana River	3	
III. MATHEMATICAL MODELING USING FLUVIAL-12	5	
Erodible Boundary Model versus Erodible Bed Model	5	
Test and Calibration of FLUVIAL-12	6	
Scope of River Modeling	8	
IV. SIMULATION OF SEDIMENT DELIVERY	10	
V. POTENTIAL CHANGES IN FLOOD LEVEL	11	
Short-Term Changes in Water-Surface without Seven Oaks Dam	11	
Short-Term Changes in Water-Surface with Seven Oaks Dam	12	
Long-Term Changes in Water-Surface without Seven Oaks Dam	13	
Long-Term Changes in Water-Surface with Seven Oaks Dam	14	
Comparison of Cross-Sectional Changes	15	
Channel Changes near Mill Creek Confluence	15	
Potential for Pit Capture	16	
VI. POTENTIAL CHANGES IN FLOODPLAIN	17	
Short-Term Changes in Floodplain Widths	17	
Short-Term Changes in Floodplain Area	21	
Long-Term Changes in Floodplain Widths	21	
Long-Term Changes in Floodplain Area	26	
Comparison of Short-Term and Long-Term Changes in Floodplain Area	27	
VII. POSSIBLE MITIGATION MEASURES	28	
Bypass Tunnel	28	
Check Dams	28	
REFERENCES	29	
LIST OF FIGURES	30	
FIGURES		
APPENDIX A		

Santa Ana River/Mentone Fan Hydrological Study

I. INTRODUCTION

A hydrological study, sponsored by the California Department of Fish and Game, was made for the Santa Ana River/Mentone Fan in San Bernardino County, California. Fig. 1 is a map showing the general area of the river and the fan. The purpose of the study was to characterize the existing and future flooding regimes and sediment transport along an eight-mile length of the river and alluvial fan. Terraces along the river and fan on surfaces of various ages support certain alluvial fan vegetation and endangered species of wildlife. Habitat renewal via flooding, scour and deposition of fine silts is considered necessary to maintain suitable habitat for spine flower over the long term. Under the natural conditions, the Mentone Fan has formed over geological time by sediment deposition during major storms. During episodes of flooding and silt deposition, the habitat has undergone renewal under the natural processes. The return period of 50 years for habitat renewal is considered essential for certain vegetation and wildlife. Flooding, scour and deposition of fresh sands is considered necessary to maintain suitable habitat for the Santa Ana River woolly star.

It is believed that the study area, under the natural conditions of the river channel, is subject to sediment deposition during storms, as evidenced by the formation of the alluvial fan. The depositional trend is expected to continue without human interference.

This river reach has been significantly disturbed by human activities in recent years. A short distance upstream from the study area, Seven Oaks Dam is under construction by the U. S. Army Corps of Engineers. In addition, there exist sand and gravel extraction in the area to supply to the material for dam construction, as well as several sand and gravel mining sites in the floodplain of the Santa Ana River. Such human activities have disturbed the natural river regime. In response to such disturbances, the river channel is expected to undergo changes thereby affecting the habitat and habitat renewal. Seven Oaks Dam will alter the storm flow of the Santa Ana River that is the

primary source of flow for the study area. Other smaller tributaries, including Mill Creek, Plunge Creek and City Creek, are not affected by the dam. Seven Oaks Reservoir will also detain nearly all the bed sediment supply to the study area. Although Seven Oaks Reservoir water storage will be released periodically, such releases will not carry significant amount of bed sediment. For this reason, Seven Oaks Reservoir will detain nearly all the bed sediment supply to the study area. Water release from Seven Oaks Reservoir will be limited in discharge and it will thus change the area of flooding in the downstream channel.

The purpose of this study was to quantify the boundaries of the 50- and 100-yr floodplains and the sediment processes under the natural and altered regime in relationship to documented populations of the two endangered plant species. In order to accomplish this objective, it is necessary to model the fluvial processes of the stream channel under its natural and altered conditions.

II. PHYSICAL DATA OF SANTA ANA RIVER

For the hydrological study, existing information on river hydrology and sedimentation were collected and reviewed. The U. S. Army Corps of Engineers study (1988) for the Santa Ana River and Seven Oaks Dam is an important document which provides the most important information on river hydrology and sedimentation.

Hydrological Data - The study reach of the river started from the area west of Norton Air Force Base and its ends at Seven Oaks Dam. In addition, Mill Creek was also included in the study. A field trip to the study area was made in the summer of 1998. The available data on the hydrology, hydraulics and geomorphology of the stream were collected and compiled. The data set for the study includes the flood hydrographs, roughness coefficients, and cross-sectional data of the river channel. The existing cross-sectional data were created from aerial survey at a large expenditure; they were used by the Corps as the data basis for floodplain study of the stream channel. The flood level and floodplain boundaries of a stream channel were established based on the channel configuration defined at the cross sections. Required data for the study were provided by various agencies in

response to requests from the California Department of Fish and Game. The following data were received:

- (1) aerial phonograph of the Santa Ana River and its vicinity from the U. S. Fish and Wildlife,
- (2) topographic maps of the river reach from the Corps of Engineers, showing locations of cross sections used in the HEC-2 study,
- (3) digitized cross-sectional data used for HEC-2 studies for the stream reach from the downstream end to the upstream end of study,
- (4) peak discharges of 10-, 50- and 100-yr floods and their variations along the study stream reach for the conditions before and after Seven Oaks Dam project,
- (5) hydrology report for the dam project from the Corps of Engineers, and
- (6) technical report by Simons, Li & Associates (1987) for the Corps that provides sediment size distributions for the river as shown in Fig. 2.

Floods of Santa Ana River - The Santa Ana River is an ephemeral river for which flood flows are short in duration. Most of the sediment movement, erosion and sedimentation, in the river channel occur during floods, especially major floods. Peak flood discharges of the river reach are summarized in Tables 1 and 2 for the pre- and post-dam conditions, respectively. In this study, the 100-yr flood (see Fig. 3) and the 50-yr flood were used to model the short-term changes.

The long-term changes, on the other hand, were modeled using a flood series representative of the long-term flood flow. In the future, one should expect various flood events. In the time span of 100 years, one may expect statistically one flood event exceeding the 100-year flood, two events exceeding the 50-year flood, four events exceeding the 25-year flood, ten events exceeding the 10-yr flood, etc. For this river reach, most of the sediment transport occurs during major floods. Those events less than the 10-yr flood have very limited discharge and hence transport capacity; therefore, only those events equal to or greater than the 10-yr flood were included in the flood series for simulation. The series of flood events occur randomly. The sequence of occurrence of these floods is beyond human prediction, but the particular order of flood events does not affect the results pertaining to the long-term sediment delivery. It was assumed in this study that the occurrence follows the following order: 10-yr flood, 30-yr flood, 20-yr flood, 40-yr flood, 15-yr flood, 100-yr

flood, 20-yr flood, 15-yr flood, 70-yr flood, and 10-yr flood. The sequences of flood events as shown in Figs. 4 and 5 were employed to represent the long-term flood flow. In this flood series, the durations of floods were shortened by excluding those portions of low flows. Since sediment transport is concentrated during periods of higher flows, such low flow durations may be discounted with no significant effect on the accuracy.

Table 1. Flood discharges of Santa Ana River before Seven Oaks Dam project

Frequency	Upstream of Mill Creek cfs	Downstream of Mill Creek cfs	Downstream of City Creek cfs
100	58,000	75,000	80,000
70	46,000	60,000	63,000
50	34,000	45,000	48,000
40	32,000	40,500	43,000
30	24,000	31,000	33,000
20	16,000	22,000	24,000
15	13,000	17,000	19,000
10	9,000	11,700	12,500

Table 2. Flood discharges of Santa Ana River after Seven Oaks Dam project

Frequency	Upstream of Mill Creek cfs	Downstream of Mill Creek cfs	Downstream of City Creek cfs
100	5,500	25,000	33,000
70	4,700	20,000	26,000
50	4,100	15,000	21,000
40	3,800	14,000	17,500
30	3,300	11,000	14,000

20	2,500	8,000	12,000
15	1,000	6,400	8,000
10	500	4,300	5,600

III. MATHEMATICAL MODELING USING FLUVIAL-12

In order to assess the impacts of Seven Oaks Dam, flood hydraulics and sediment processes of the river channel were simulated using the computer model FLUVIAL-12 (Chang, 1988) for the pre- and post-dam conditions of the river channel. The FLUVIAL-12 model has been formulated and developed since 1972 for water and sediment routing in natural and man-made channels. The combined effects of flow hydraulics, sediment transport, and river channel changes are simulated for a given flow period. River channels changes simulated by the model include channel-bed scour and fill (or aggradation and degradation), width variation, and changes in bed topography induced by the curvature effect. These inter-related changes are coupled in the model for each time step. While this model is for erodible channels, physical constraints, such as bank protection, grade-control structures and bedrock outcroppings, may also be specified. Applications of this model include evaluations of general scour at bridge crossings, sediment delivery, channel responses to sand and gravel mining, channelization, etc.

This model is applicable to ephemeral rivers as well as rivers with perennial flow; it has also been tested and calibrated with field data from several rivers, in both semi-arid and humid regions. Because of the transient behavior in dynamic changes, ephemeral rivers require more complicated techniques in model formulation. This model may be used on any main frame computer; it may also be used on a personal computer with adequate capacity.

Erodible Boundary Model versus Erodible Bed Model - The FLUVIAL-12 model is an *erodible-boundary model*; it simulates inter-related changes in channel-bed profile, channel width, and bed topography induced by the channel curvature. The erodible-boundary model is different from an *erodible-bed model*, such as the HEC-6 model, in the following ways.

- (1) An erodible-bed model does not simulate changes in channel width. Since changes in channel-bed profile is closely related to changes in width, these changes may not be separated.
- (2) The change in bed profile in an erodible-bed model is assumed to be uniform in the erodible zone. All points adjust up and down by an equal amount during aggradation and degradation. Actual bed changes are by no means uniform and therefore they may not be simulated by an erodible-bed model.
- (3) An erodible-bed model does not consider the channel curvature. In reality, the bed topography is highly non-uniform in a curved channel, especially during a high flow.
- (4) The erodible zone needs to be specified at all cross sections in an erodible-bed model. This means the model does not provide the extent of erosion in the channel, but the user has to inform the model about the erodible part of the channel bed. The boundary of erosion is computed and provided by the FLUVIAL-12 model, this boundary changes with the discharge and time.
- (5) Sediment inflow into the channel reach needs to be specified for many other models. This requires the sediment rating curve which is usually not available for stream channels. In the FLUVIAL-12 model, the sediment inflow may be specified and it may also be computed based on the hydraulics of flow at the upstream section at every time step.

Test and Calibration of FLUVIAL-12 - The FLUVIAL-12 has been calibrated using many sets of river data as listed below. An erodible-bed model may not be calibrated with field data of natural streams.

- (1) Test and Calibration Study Using Data from the San Diego River in Southern California. Chang, H. H., 1982, "Mathematical Model for Erodible Channels", *Journal of the Hydraulics Division*, ASCE, 108(HY5), 678-689. Closure in 109(HY4), 655-656.
- (2) Test and Calibration Study Using Data from the Inlet Channel of San Elijo Lagoon in Southern

California. Chang, H. H., and Hill, J. C., 1977, "Minimum Stream Power for Rivers and Deltas," *Journal of the Hydraulics Division*, ASCE, 103(HY12), 1375-89.

- (3) Test and Calibration Study Using Data from the San Dieguito River in Southern California. Chang, H. H., 1984, "Modeling of River Channel Changes", *Journal of Hydraulic Engineering*, ASCE, 110(2), 157-172. Closure in 113(2), 1987, 265-267.
- (4) Test and Calibration Study Using Data from the San Lorenzo River in Northern California. Chang, H. H., 1985, "Water and Sediment Routing through Curved Channels", *Journal of Hydraulic Engineering*, ASCE, 111(4), 644-658.
- (5) Test and Calibration Study Using Data from San Juan Creek in Southern California. Chang, H. H., 1987, "Modeling Fluvial Processes in Streams with Gravel Mining," in *Sediment Transport in Gravel-Bed Rivers*, Thorne, et al. editors, John Wiley & Sons, pp. 977-988. Also presented at the International Workshop on Problems of Sediment Transport in Gravel-Bed River, Colorado State University, August 12-17, 1985.
- (6) Test and Calibration Using the Missouri River Data in Iowa. Chang, H. H., 1988, "Test and Calibration Study of the FLUVIAL Model Using the Missouri River Data", Prepared for the Waterways Experiment Station, U.S. Army Corps of Engineers, Under Contract "Computer-Based Design of River Bank Protection", No. DACW39-87-0039.
- (7) Test and Calibration Study Using Data from the Santa Clara River in Southern California. Chang, H. H. and Stow, D., 1989, "Mathematical Modeling of Fluvial Sediment Delivery", *Journal of Waterway, Port, Coastal, and Ocean Engineering*, ASCE, 115(3), 311-326.
- (8) Test and Calibration Study Using Data from the Fall River in Colorado. Chang, H. H., 1991, "Simulation of Bed Topography in a Meandering River", *Proceedings of the Fifth Interagency Sedimentation Conference*, Las Vegas, NV, March 21-28.

- (9) Test and Calibration Study Using Data from the San Luis Rey River in Southern California. Chang, H. H., 1991, "Computer Simulation of River Channel Changes Induced by Sand Mining", *Proceedings of International Conference on Computer Applications in Water Resources*, July 3-6, Taipei, Taiwan, Vol. 1, 226-234.
- (10) Test and Calibration Study Using Data from Stony Creek in Northern California. Chang, H. H., Harris, C., Lindsay, W., Nakao, S. S., and Kia, R., 1993, "Selecting Sediment Transport Equation for Scour Simulation at Bridge Crossing", *Proceedings of the 1993 National Conference on Hydraulic Engineering*, San Francisco, CA, July 25-30, pp. 1744-1949. Chang, H. H., 1994, "Selection of Gravel-Transport Formula for Stream Modeling", *Journal of Hydraulic Engineering*, ASCE, Vol. 120, No. 5, May, pp. 646-651.
- (11) Test and Calibration Study Using Data from the Feather River in Northern California. Chang, H. H., 1993, "Numerical Modeling for Sediment-Pass-Through Operations of Reservoirs on North Fork Feather River", prepared for Pacific Gas & Electric Company, San Francisco. Chang, H. H., Harrison, L., Lee, W., and Tu, S., 1996, "Numerical Modeling for Sediment-Pass-Through Reservoirs", *Journal of Hydraulic Engineering*, ASCE, Vol. 122, No. 7, pp. 381-388.
- (12) Test and Calibration Study Using Data from the San Dieguito River in Southern California for the 1993 Floods. Chang, H.H., 1994, "Test and Calibration of FLUVIAL-12 Model Using Data from the San Dieguito River", prepared for Southern California Edison Company.
- (13) Test and Calibration Study Using Data from a Tidal Inlet with Oscillating Tidal Flow. Chang, H. H., 1997, "Modeling Fluvial Processes in Tidal Inlet", *Journal of Hydraulic Engineering*, ASCE, Vol. 123, No. 12, pp. 1161-1165.

Scope of River Modeling - Modeling study of the river channel was made for the following scenarios:

Scenario 1. Existing conditions of the river channel before Seven Oaks Dam project.

Scenario 2. Future conditions of the river channel after the completion of Seven Oaks Dam.

River channel changes including changes in water-surface profile and channel boundary were modeled using FLUVIAL-12. Such changes include short-term changes and long-term changes. The modeling bases for these changes are described below:

Short term changes: Such changes were modeled using the 50-yr and the 100-yr floods, respectively.

Long term changes: Such changes were modeled using a flood series in the 100-yr time span.

Hydrographs of the flood series for the conditions before Seven Oaks Dam are shown in Fig. 4; those for the conditions after Seven Oaks Dam are shown in Fig. 5. By comparing the flood discharges for the before and after conditions, it is easy to see that the dam project contributes to major reductions of the flood discharge.

A total of ten cases were identified for modeling as given below.

Case 1. Water-surface profile of river channel for the 100-yr flood before Seven Oaks Dam assuming rigid channel boundary

Case 2. Water-surface profile of river channel for the 100-yr flood before Seven Oaks Dam assuming erodible channel boundary

Case 3. Water-surface profile of river channel for the 100-yr flood after Seven Oaks Dam assuming erodible channel boundary

Case 4. Water-surface profile of river channel for the 50-yr flood before Seven Oaks Dam assuming rigid channel boundary

Case 5. Water-surface profile of river channel for the 50-yr flood before Seven Oaks Dam assuming erodible channel boundary

Case 6. Water-surface profile of river channel for the 50-yr flood after Seven Oaks Dam assuming erodible channel boundary

Case 7. The 100-yr flood profile of river channel after 100 years without Seven Oaks Dam assuming erodible channel boundary

Case 8. The 100-yr flood profile of river channel after 100 years with Seven Oaks Dam assuming erodible channel boundary

Case 9. The 50-yr flood profile of river channel after 100 years without Seven Oaks Dam assuming erodible channel boundary

Case 10. The 50-yr flood profile of river channel after 100 years with Seven Oaks Dam assuming erodible channel boundary.

IV. SIMULATION OF SEDIMENT DELIVERY

Sediment delivery is defined as the cumulative amount of sediment that has been delivered passing a certain channel section for a specified period of time, that is,

$$Y = \int_T Q_s dt \quad (1)$$

where Y is sediment delivery (yield); Q_s is sediment discharge; t is time; and T is the duration. The sediment discharge Q_s pertains only to bed-material load of sand, gravel and cobble. Fine sediment of clay and silt constitute the wash load may not be computed by a sediment transport formula. Sediment delivery is widely employed by hydrologists for watershed management; it is used herein to keep track of sediment supply and removal along the channel reach.

Spatial variations in sediment delivery are manifested as channel storage or depletion of sediment associated stream channel changes since the sediment supply from upstream may be different from the removal. The spatial variation of sediment delivery depicts the erosion and deposition along a stream reach. A decreasing delivery in the downstream direction, i.e. negative gradient for the delivery-distance curve, signifies that sediment load is partially stored in the channel to result in a net deposition. On the other hand, an increasing delivery in the downstream direction (positive gradient for the delivery-distance curve) indicates sediment removal from the channel boundary or net scour. A uniform sediment delivery along the channel (horizontal curve) indicates sediment balance, i.e., zero storage or depletion. Channel reaches with net sediment storage or depletion may be designated in each figure on the basis of the gradient. From the engineering

viewpoint, it is best to achieve a uniform delivery, the non-silt and non-scour condition, for dynamic equilibrium.

In the absence of Seven Oaks Dam, sediment delivery along the Santa Ana River as shown in Fig. 6 has a general decreasing trend toward downstream. Within the general trend, there are short channel reaches where the trend is the opposite. Therefore, sediment deposition can be expected along most of the river channel reach with a few exceptions. The general trend of sediment deposition also means that the flood level will become higher in the future. The pattern of sediment delivery along Mill Creek has a clearly decreasing trend toward downstream; therefore, this stream channel is expected to undergo sediment deposition and aggradation.

With the presence of Seven Oaks Dam, the sediment delivery as shown in Fig. 7 has an erosional trend along the Santa Ana River from the dam site down to river mile 35.3. This erosional trend is related to the detention of sediment by the reservoir. Erosion of the channel boundary will also contribute to a reduction of the flood level. For the post-dam conditions, the sediment delivery along Mill Creek still has a clearly decreasing trend. This stream channel is basically unaffected by Seven Oaks Dam; it is expected to undergo sediment deposition and aggradation for the post-dam conditions.

V. POTENTIAL CHANGES IN FLOOD LEVEL

Since Seven Oaks Dam will cause changes in downstream flood discharge and sediment supply, there should also be associated changes in flood level along the downstream channel. Such potential changes in flood level were modeled for several case scenarios and the results are described below.

Short-Term Changes in Water-Surface without Seven Oaks Dam - In order to assess potential long-term changes in water-surface in the absence of Seven Oaks Dam, water-surface profiles for cases 1 and 2 pertaining to the 100-yr flood were modeled and their results were compared. These cases were modeled based on the single 100-yr flood, therefore, they are for short-

term changes. The computed water-surface elevations for these cases are listed in Table A-1 in Appendix A together with their differences. The changes in 100-yr flood level along the Santa Ana River and Mill Creek are also shown graphically in Fig. 8. It can be seen from the figure that the short-term changes in water-surface elevation are generally small. Rises and drops in the 100-yr flood elevation are roughly equal.

Water-surface profiles for cases 4 and 5 pertaining to the 50-yr flood are now compared. The computed water-surface elevations for these cases are listed in Table A-2 together with their differences. Comparisons in water-surface elevation are also depicted graphically as shown in Fig. 9. It can be seen from the figure that the short-term changes in water-surface elevation are generally small. Rises and drops in the 50-yr flood elevation are approximately equal.

Based on the modeled results for the 50-yr and 100-yr floods, it may be concluded that the river channels of Santa Ana River and Mill Creek are expected to undergo minor short-term changes without the presence of Seven Oaks Dam. In addition, the rises and drops in the 50- and 100-yr flood levels are roughly equal.

Short-Term Changes in Water-Surface with Seven Oaks Dam - In order to assess potential short-term changes in water-surface with the presence of Seven Oaks Dam, water-surface profiles for cases 1 and 3 pertaining to the 100-yr flood are now compared. These cases were modeled based on the 100-yr flood; therefore, they pertain to short-term changes. The computed water-surface elevations for these cases are listed in Table A-3 together with their differences. Comparisons in water-surface elevation are also depicted graphically as shown in Fig. 10. It can be seen from the figure that the short-term changes in water-surface elevation with the presence of the dam are generally greater than those for the case without the dam. Drops in the 100-yr flood elevation are predicted to occur at most locations along the Santa Ana River. Such drops are more pronounced near the dam and they tend to taper off with distance. Flood levels along Mill Creek are basically unaffected by the dam.

Water-surface profiles for cases 4 and 6 pertaining to the 50-yr flood are now compared. The

computed water-surface elevations for these cases are listed in Table A-4 together with their differences. Graphical comparison of the water-surface elevations is shown in Fig. 11. It can be seen from the figure that the short-term changes in water-surface elevation with the presence of the dam are generally greater than those for the case without the dam. Drops in the 50-yr flood elevation are predicted to occur at most locations along the Santa Ana River. Such drops are more pronounced near the dam and they tend to taper off with distance. Flood levels along Mill Creek are basically unaffected by the dam.

Based on these results, it may therefore be concluded that Seven Oaks Dam will cause a significant short-term lowering of the 50-yr and 100-yr flood profiles along the Santa Ana River.

- This tendency is primarily related to the reduction of the flood discharge. Channel-bed erosion also contributes to the lowering the flood profile.

Long-Term Changes in Water-Surface without Seven Oaks Dam - In order to assess potential long-term changes in water-surface in the absence of Seven Oaks Dam, water-surface profiles for cases 1 and 7 pertaining to the 100-yr flood are now compared. Case 7 was modeled based on the 100-yr flood series, therefore, the results are for long-term changes. The computed water-surface elevations for these cases are listed in Table A-5 in Appendix A together with their differences. The changes in 100-yr flood level along the Santa Ana River and Mill Creek are also shown graphically in Fig. 12. Water-surface profile at peak flow and channel-bed changes during the flood series are show in Fig. A-1. Sample cross-sectional changes during 100-yr flood series are shown in Fig. A-3.

It can be seen from Fig. 12 that the long-term changes in water-surface elevation are generally small. Rises in the 100-yr flood elevation are predicted to occur at most locations.

Water-surface profiles for cases 4 and 9 pertaining to the 50-yr flood are now compared. The computed water-surface elevations for these cases are listed in Table A-6 together with their differences. Comparisons in water-surface elevation are also depicted graphically as shown in Fig. 13. It can be seen from the figure that the changes in water-surface elevation are generally small

in the next 100 years. Rises in the 50-yr flood elevation are predicted to occur at most locations.

Based on these results for long-term changes, it may be concluded that there is a natural tendency for gradual rises of the 50- and 100-yr flood levels along the Santa Ana River and Mill Creek in the absence of Seven Oaks Dam. This natural tendency is closely related to the generally depositional trend for sediment along the channel reach.

Long-Term Changes in Water-Surface with Seven Oaks Dam - In order to assess potential long-term changes in water-surface with the presence of Seven Oaks Dam, water-surface profiles for cases 1 and 8 pertaining to the 100-yr flood are now compared. Case 8 was modeled based on the 100-yr flood series; therefore, the results pertain to long-term changes. The computed water-surface elevations for these cases are listed in Table A-7 together with their differences. Comparisons in water-surface elevation are also depicted graphically as shown in Fig. 14.

It can be seen from Figs. 12 and 14 that long-term changes in water-surface elevation with the presence of the dam are significantly different from those for the case without the dam. While the water surface shows a generally rising trend for the case without the dam, the opposite trend is true for the case with the presence of the dam. As shown in Fig. 14, drops in the 100-yr flood elevation are predicted to occur at most locations along the Santa Ana River. Such drops are more pronounced near the dam and they tend to taper off with distance. Near the confluence of the Santa Ana River and Mill Creek, the water surfaces show distinct rises. Such a development is explained in the next section.

Water-surface profiles for cases 4 and 10 pertaining to the 50-yr flood are now compared. The computed water-surface elevations for these cases are listed in Table A-8 together with their differences. Graphical comparisons of water-surface elevations are shown in Fig. 15.

It can be seen from Figs. 13 and 15 that the long-term changes in water-surface elevation with the dam are generally greater than those for the case without the dam. While the water surface shows a generally rising trend for the case without the dam, the opposite trend is true for the case

with the presence of the dam. As shown in Fig. 15, drops in the 50-yr flood elevation are predicted to occur at most locations along the Santa Ana River. Such drops are more pronounced near the dam and they tend to taper off with distance. Along Mill Creek, the water surface shows distinct rises near the confluence.

Based on these results, it may be concluded that Seven Oaks Dam will cause a significant lowering of the 50- and 100-yr flood profiles along most of the Santa Ana River. This long-term trend of change is closely related to the increased channel bed erosion and reduction of the flood discharge.

Comparison of Cross-Sectional Changes - Changes in cross-section geometry of the river channel were simulated for the cases before and after dam project. Sample cross-sectional changes during the 100-yr flood series are shown in Fig. A-3. The cross-sectional geometries are characterized by a main channel and overbank, or floodplain, areas. When cross-sectional changes at each location before the dam project are compared with those after the dam project, it is easy to see that there tends to be more sediment deposition on the overbank areas for the case before the dam project. Also, there tends to be more scour of the main channel for the case after the dam project. These trends are less pronounced at those locations farther downstream, but they are very pronounced at locations just below the dam, as exemplified by the changes for section 39.35.

Channel Changes near Mill Creek Confluence - Seven Oaks Dam is on the Santa Ana River above the Mill Creek confluence. While the dam affects the flood discharge and sediment supply of the Santa Ana River, the sediment and flood flows of Mill Creek are unaffected. Seven Oaks Dam reduces the downstream flood discharge and it also cuts off sediment supply to the downstream channel. With the sediment supply cut off, the downstream channel is expected to undergo erosion. However, changes in the downstream channel after the Mill Creek confluence are also affected by water and sediment inflows from Mill Creek. Modeling results for channel changes near the confluence are described below.

The channel morphology near the confluence adjusts according to the water and sediment

flows of both streams. Under the natural conditions before the dam, the stream channels reached an approximate equilibrium through continued adjustments in geologic time. The natural hydrologic and sediment regimes are altered with the presence of the dam.

Since Mill Creek is not controlled by the dam, the water and sediment flows reaching the confluence from Mill Creek are unchanged. However, the water and sediment flows from the Santa Ana River reaching the confluence are greatly reduced.

Sediment transport rate Q_s is directly related to the water discharge Q raised to a power, i.e.,

$$Q_s \propto Q^n \quad (2)$$

The value of the exponent n varies, but it is around 2. This relation shows that a reduction of the flood discharge is accompanied by a much greater reduction of sediment transport capacity.

When these two streams meet at the confluence, the combined flow after the dam is lower than the natural flow but the combined sediment transport capacity is much lower than the natural sediment transport capacity. For this reason, sediment supply from Mill Creek will partially settle out at the confluence to form a delta. This deposition will then induce backwater effects and deposition in the upstream channels. The modeled changes in channel-bed profiles near the confluence are shown in Figs. 16 and 17. These figures depict channel-bed aggradation at and above the confluence and degradation downstream of the confluence.

Potential for Pit Capture - There exist many gravel pits along the study reach of the Santa Ana River. These borrow pits are separated from the main channel by a certain distance. If flood flow should enter a pit, then pit capture (A stream is diverted from its normal course into a pit of lower elevation) would occur and it would induce scour in the adjacent river channel. In order to determine if flood flow would enter into these pits, the computed flood levels near the gravel pits were compared with the terrain between the channel and the pits. It was concluded that the terrain has adequate height so that it would not be overtopped by the 100-yr flood. The separation

distances between the channel and these pits are generally large except along the reach near river mile 33.5, where this separation is unlikely to be breached during short-term changes but it may be breached in the long term. After the dam project, the river channel will become more stable in its alignment and the flood level will also be lower. In summary, there exists the potential for pit capture in the long term but such chances will be reduced by the dam project.

VI. POTENTIAL CHANGES IN FLOODPLAIN

Short-Term Changes in Floodplain Widths - Changes in flood level is accompanied by corresponding changes in floodplain widths. Floodplain widths are compared for the following cases pertaining to short-term changes:

Case 2. Floodplain widths for the 100-yr flood before Seven Oaks Dam assuming erodible channel boundary

Case 3. Floodplain widths for the 100-yr flood after Seven Oaks Dam assuming erodible channel boundary

Case 5. Floodplain widths for the 50-yr flood before Seven Oaks Dam assuming erodible channel boundary

Case 6. Floodplain widths for the 50-yr flood after Seven Oaks Dam assuming erodible channel boundary

A comparison of floodplain widths for cases 3 and 4 pertaining to the 100-yr flood is shown in Fig. 18. Another comparison for cases 5 and 6 pertaining to the 50-yr flood is shown in Fig. 19. Numerical values for the floodplain widths are summarized in Table 3. It can be seen from these comparisons that the floodplain widths are generally smaller along the Santa Ana River with the presence of the dam. Floodplain width for Mill Creek is basically unaffected by the dam. The reduction in floodplain width for Santa Ana River is attributed to the lower flood discharges and greater channel-bed erosion associated with the presence of the dam.

Table 3. Short-term changes in floodplain width related to Seven Oaks Dam

Section No. river miles	Floodplain width for 100-yr flood, ft			Floodplain width for 50-yr flood, ft		
	Without dam	With dam	Difference	Without dam	With dam	Difference
29.64	650	593	-56	614	595	-18
29.80	1572	627	-944	1255	616	-638
29.99	2454	1936	-518	2143	1680	-463
30.12	2419	1471	-947	2347	836	-1511
30.26	2324	683	-1640	2307	622	-1685
30.38	2507	2135	-371	2464	1200	-1263
30.45	931	616	-315	630	605	-25
30.56	2625	2224	-400	2572	1890	-681
30.63	702	682	-20	698	690	-7
30.75	2329	2216	-113	2317	2011	-306
30.88	2144	2137	-6	2167	2107	-59
31.02	889	841	-48	866	817	-49
31.13	1102	1075	-26	1090	1028	-62
31.23	1211	1197	-13	1109	1121	12
31.33	898	846	-52	870	843	-27
31.47	1244	1085	-159	1192	622	-570
31.63	1429	1162	-266	1294	1141	-152
31.71	1227	968	-259	1044	870	-174
31.83	1516	1258	-258	1347	1249	-97
31.96	1572	1007	-565	1038	983	-54
32.04	1679	1455	-223	1413	1347	-65
32.17	2602	2046	-555	2261	1937	-324
32.27	1923	1679	-244	1848	900	-947
32.37	1690	1185	-505	1251	1164	-87
32.45	1864	1003	-861	1468	961	-506
32.55	1632	1128	-503	1159	954	-204
32.65	1607	1403	-204	1456	1113	-342
32.77	269	178	-90	218	75	-142
32.81	1851	1558	-293	1710	1057	-652
32.99	1798	1683	-114	1755	947	-808
33.12	1122	1101	-20	1069	906	-163
33.17	999	925	-74	983	903	-80
33.28	761	706	-54	736	623	-113
33.31	860	471	-388	755	636	-119
33.37	1053	752	-300	854	753	-101
33.44	1067	852	-215	947	513	-434
33.49	1177	1053	-124	1099	1017	-82
33.54	1073	485	-587	874	388	-485
33.61	1185	1086	-99	1133	1070	-63
33.66	1230	658	-572	1134	657	-477
33.72	1081	835	-246	1057	525	-531
33.77	1108	1096	-11	1112	1079	-32
33.81	1203	1113	-89	1157	630	-526

33.87	1489	1207	-281	1283	1059	-224
33.94	2274	2088	-186	2183	278	-1905
34.00	1936	1536	-400	1855	173	-1682
34.09	1778	1611	-166	1675	154	-1521
34.17	1677	556	-1121	1785	222	-1562
34.27	1290	180	-1109	1317	182	-1134
34.36	572	207	-364	422	183	-239
34.39	598	2995	2396	3350	2854	-496
34.45	4461	2491	-1969	2980	2052	-928
34.51	3947	3330	-617	3674	1874	-1800
34.65	2659	1741	-917	1951	605	-1345
34.70	2616	1272	-1344	468	342	-125
34.76	1336	1020	-315	919	413	-506
34.81	992	550	-441	688	550	-138
34.86	1923	565	-1357	814	619	-194
34.91	1063	904	-159	1019	872	-146
34.98	1912	301	-1610	1846	382	-1463
35.04	1507	1453	-53	1481	567	-914
35.09	1699	466	-1233	1662	273	-1389
35.15	1643	1032	-611	1318	161	-1156
35.19	1380	1268	-111	1324	1253	-70
35.29	1306	1038	-268	1216	535	-681
35.39	240	1254	1014	1445	1325	-119
35.51	1420	1348	-72	269	1277	1007
35.56	1719	1669	-49	242	409	167
35.61	1589	1413	-175	199	1333	1134
35.72	1511	1097	-414	1064	491	-573
35.81	1459	1010	-449	1427	973	-454
35.88	1324	918	-405	923	353	-569
35.95	1318	304	-1013	418	710	291
36.02	462	132	-329	144	122	-21
36.06	295	291	-4	1712	244	-1468
36.10	1455	295	-1159	1191	300	-890
36.15	397	417	19	438	267	-171
36.22	1094	307	-787	436	243	-193
36.29	1167	417	-750	492	344	-147
36.36	820	614	-206	817	451	-366
36.41	1437	1237	-199	665	1058	393
36.48	547	1830	1282	1877	517	-1360
36.51	956	919	-37	918	772	-146
36.57	780	779	-1	2417	760	-1657
36.61	872	946	74	2525	929	-1596
36.67	2937	2242	-695	3300	765	-2534
36.73	4707	939	-3768	1191	440	-751
36.81	989	744	-245	917	534	-383
36.88	2704	2582	-121	2415	2590	175
36.98	3254	2911	-343	3219	2474	-744
37.04	3034	2104	-930	3008	1985	-1023
37.09	2779	599	-2180	2746	1113	-1633

37.17	683	831	147	958	593	-364
37.24	2016	1001	-1015	1219	602	-617
37.31	2348	1424	-923	1639	276	-1362
37.36	1841	1303	-537	1339	479	-860
37.39	1854	1022	-832	1208	453	-755
37.45	1563	901	-662	1046	746	-300
37.49	1502	697	-804	1381	623	-757
37.56	1658	1012	-646	1087	273	-814
37.63	1357	981	-376	1143	471	-671
37.67	1116	1075	-40	1082	418	-663
37.72	1132	848	-284	868	277	-591
37.79	1215	662	-552	870	396	-473
37.83	1088	908	-180	921	673	-248
37.91	1140	574	-565	639	585	-54
37.97	1477	479	-997	866	417	-448
38.04	915	462	-453	1253	513	-739
38.11	1621	1557	-63	1210	921	-289
38.17	1667	1606	-61	308	647	339
38.22	1549	91	-1458	495	84	-410
38.30	310	402	92	1421	398	-1022
38.37	321	414	93	1040	366	-673
38.47	460	206	-253	824	307	-516
38.54	444	355	-89	524	320	-203
38.61	432	153	-279	563	112	-451
38.66	324	188	-135	333	317	-16
38.71	494	432	-62	273	440	167
38.79	854	436	-417	751	393	-357
38.83	1172	218	-954	1109	160	-949
38.86	1246	243	-1002	467	244	-223
38.92	1132	588	-544	1102	278	-824
38.97	1202	371	-830	1197	378	-819
39.05	1185	140	-1044	1106	134	-971
39.10	907	184	-722	860	157	-703
39.15	719	234	-485	638	226	-412
39.18	550	295	-255	532	289	-242
39.24	249	210	-39	249	208	-41
39.35	439	128	-311	438	137	-301
39.42	572	105	-466	574	218	-356
39.49	589	286	-303	552	238	-313

The following sections are in Mill Creek

38.22	290	448	157	211	443	232
38.28	427	477	49	370	434	64
38.34	423	428	5	374	378	3
38.44	385	388	3	374	374	0
38.52	310	314	3	292	292	0
38.60	322	325	3	312	310	-2
38.64	264	270	5	251	250	-1
38.69	294	295	1	282	283	0
38.77	325	322	-2	295	296	0

38.83	481	523	41	338	349	11
38.91	451	441	-9	395	395	0
38.96	384	385	1	365	368	3
39.07	467	469	2	438	436	-2
39.19	572	571	0	427	427	0
39.27	566	567	0	510	504	-6
39.36	686	688	1	619	632	12
39.43	886	871	-14	779	766	-12
39.51	868	876	7	865	861	-4
39.56	615	608	-6	613	553	-60
39.63	461	459	-2	450	449	-1
39.68	323	323	0	309	319	10
39.76	216	219	3	195	198	2
39.83	160	160	0	160	160	0
39.91	333	359	25	252	264	12
40.00	485	531	46	424	435	11
40.08	549	550	0	403	404	1
40.16	776	779	3	764	762	-1
40.28	539	552	12	488	492	3

Short-Term Changes in Floodplain Area - Floodplain areas were computed by integrating the floodplain width with channel length. Such areas were obtained for the incremental channel length of one half-mile covering cases 2, 3, 5, and 6. Floodplain areas for cases 2 and 3 pertaining to the 100-yr flood are compared as shown in Fig. 20; those for cases 5 and 6 pertaining to the 50-yr flood are compared as shown in Fig. 21. Numerical values of the areas are submarine in Table 4. It can be seen from these comparisons that the floodplain areas along the Santa Ana River are generally smaller with the presence of the dam. Floodplain area for Mill Creek is basically unaffected by the dam. The reduction in floodplain area for Santa Ana River is attributed to the lower flood discharges and greater channel-bed erosion associated with the presence of the dam.

Long-Term Changes in Floodplain Widths - Changes in flood level is accompanied by corresponding changes in floodplain widths. Floodplain widths are compared for the following cases pertaining to long-term changes:

Case 7. Floodplain widths for the 100-yr flood after 100 years without Seven Oaks Dam assuming erodible channel boundary

Case 8. Floodplain widths for the 100-yr flood after 100 years with Seven Oaks Dam assuming erodible channel boundary

Case 9. Floodplain widths for the 50-yr flood after 100 years without Seven Oaks Dam assuming erodible channel boundary

Case 10. Floodplain widths for the 50-yr flood after 100 years with Seven Oaks Dam assuming erodible channel boundary.

Table 4. Short-term changes in floodplain area related to Seven Oaks Dam

Half mile reach starting river miles	Floodplain area for 100-yr flood acres			Floodplain area for 50-yr flood acres		
	Without dam	With dam	Difference	Without dam	With dam	Difference
30.0	126.3	76.0	-50.3	121.4	53.0	-68.4
30.5	98.7	93.5	-5.2	98.1	87.9	-10.2
31.0	67.7	63.0	-4.7	64.5	53.7	-10.8
31.5	83.7	65.1	-18.6	69.2	62.8	-6.4
32.0	98.7	73.7	-25.0	82.5	61.6	-20.9
32.5	81.6	71.2	-10.4	74.9	46.8	-28.1
33.0	59.5	51.1	-8.4	54.8	44.8	-10.0
33.5	86.4	70.1	-16.3	81.1	39.2	-41.9
34.0	100.3	71.1	-29.2	100.6	44.3	-56.3
34.5	118.9	67.6	-51.3	80.3	34.8	-45.4
35.0	66.7	62.7	-4.0	65.0	46.0	-19.0
35.5	76.2	53.1	-23.1	40.5	35.9	-4.6
36.0	49.6	40.2	-9.4	50.0	25.0	-25.0
36.5	139.8	99.7	-40.1	133.4	78.6	-54.8
37.0	121.9	68.2	-53.7	99.2	44.9	-54.3
37.5	70.7	43.4	-27.3	52.5	25.5	-27.0
38.0	47.3	34.3	-13.0	50.4	24.1	-26.3
38.5	50.2	19.6	-30.6	44.6	17.5	-27.1
The following is for Mill Creek						
38.0	28.0	30.0	2.0	24.0	25.0	1.0

A comparison of floodplain widths for cases 7 and 8 pertaining to the 100-yr flood is shown in Fig. 22. Another comparison for cases 9 and 10 pertaining to the 50-yr flood is shown in Fig. 23. Numerical values for the floodplain widths are summarized in Table 5. It can be seen from these comparisons that the floodplain widths are generally smaller along the Santa Ana River with the presence of the dam. Floodplain width for Mill Creek is basically unaffected by the dam. The reduction in floodplain width for Santa Ana River is attributed to the lower flood discharges and greater channel-bed erosion associated with the presence of the dam.

Table 5. Long-term changes in floodplain width related to Seven Oaks Dam

Section No. river miles	Floodplain width for 100-yr flood, ft			Floodplain width for 50-yr flood, ft		
	Without dam	With dam	Difference	Without dam	With dam	Difference
29.64	668	609	-59	663	606	-57
29.80	1746	637	-1108	806	625	-181
29.99	2691	1945	-746	2487	1785	-701
30.12	2514	2449	-65	2490	2408	-81
30.26	2380	2329	-51	2320	857	-1462
30.38	2496	2460	-36	2111	2377	265
30.45	2274	639	-1634	1504	637	-867
30.56	2633	2602	-31	2514	2472	-41
30.63	784	705	-78	777	704	-73
30.75	2502	2450	-52	2455	2433	-22
30.88	2209	2160	-48	2097	2155	57
31.02	1880	880	-999	1813	866	-947
31.13	1265	1083	-182	1228	1077	-151
31.23	1208	1198	-10	1123	1174	50
31.33	1003	884	-119	964	776	-188
31.47	1810	1130	-680	1282	1020	-261
31.63	1471	1263	-208	1458	1223	-234
31.71	1496	1079	-416	824	944	120
31.83	1579	1314	-264	1545	999	-545
31.96	1604	1023	-581	1590	1010	-580
32.04	1695	1337	-358	1633	642	-991
32.17	2610	2123	-487	1661	1142	-519
32.27	1941	1717	-223	926	1439	513
32.37	2006	1281	-725	1591	1192	-399
32.45	2074	1438	-635	1329	554	-774
32.55	2080	1486	-594	931	1290	359
32.65	3141	1688	-1452	1015	1560	545
32.77	2161	924	-1237	496	349	-147
32.81	1815	1219	-596	728	323	-405
32.99	1703	1681	-21	486	1102	615

33.12	1107	1080	-26	1002	1021	19
33.17	926	945	19	746	916	169
33.28	800	753	-46	800	565	-234
33.31	854	553	-301	796	458	-338
33.37	1037	535	-501	897	409	-488
33.44	1063	861	-202	981	755	-226
33.49	1171	557	-614	834	480	-353
33.54	1200	561	-639	932	370	-561
33.61	1096	561	-534	1101	511	-590
33.66	1344	275	-1069	969	270	-699
33.72	1102	329	-772	1091	251	-840
33.77	1316	279	-1036	1115	251	-863
33.81	1219	1107	-112	1175	230	-944
33.87	1571	364	-1207	1279	280	-998
33.94	2469	298	-2170	827	276	-550
34.00	2237	487	-1749	940	355	-585
34.09	2019	403	-1616	697	341	-356
34.17	1862	485	-1377	578	368	-209
34.27	1082	318	-763	892	309	-583
34.36	714	313	-401	692	306	-385
34.39	3708	3247	-461	895	323	-572
34.45	4549	2434	-2114	716	352	-364
34.51	4118	3696	-421	4070	311	-3759
34.65	3894	1656	-2238	3788	1622	-2166
34.70	3783	1680	-2102	540	511	-29
34.76	2971	971	-2000	2923	377	-2546
34.81	3214	652	-2561	795	338	-457
34.86	4222	741	-3481	984	286	-698
34.91	1087	955	-132	725	223	-502
34.98	2040	1798	-241	548	281	-266
35.04	2098	464	-1633	948	356	-592
35.09	2216	319	-1897	487	308	-179
35.15	1868	402	-1466	1847	326	-1520
35.19	2187	320	-1867	867	301	-565
35.29	2097	362	-1735	525	288	-237
35.39	1641	224	-1416	361	208	-153
35.51	1727	430	-1296	386	349	-36
35.56	1781	249	-1531	411	238	-173
35.61	2309	298	-2010	417	239	-177
35.72	1615	546	-1069	379	200	-179
35.81	1582	238	-1344	410	194	-216
35.88	904	291	-613	618	249	-368
35.95	557	231	-326	503	225	-277
36.02	729	115	-613	580	94	-485
36.06	844	504	-340	627	208	-419
36.10	580	303	-276	562	280	-282
36.15	686	240	-445	611	211	-399
36.22	1358	304	-1053	635	246	-388
36.29	1201	331	-870	1179	279	-900

36.36	999	295	-704	846	282	-564
36.41	1649	261	-1387	1551	231	-1320
36.48	2016	270	-1746	544	239	-305
36.51	1782	293	-1489	1616	230	-1385
36.57	2690	728	-1962	2564	226	-2338
36.61	2704	867	-1837	2532	289	-2243
36.67	3664	2252	-1412	3519	290	-3228
36.73	4710	1057	-3653	690	164	-526
36.81	4228	619	-3609	560	375	-185
36.88	3027	185	-2841	440	176	-263
36.98	3226	2861	-365	625	73	-552
37.04	3054	398	-2656	3043	263	-2780
37.09	2786	2765	-21	583	236	-346
37.17	2426	881	-1545	705	317	-388
37.24	2235	967	-1267	2220	353	-1866
37.31	700	567	-132	696	484	-211
37.36	1152	282	-869	1020	263	-757
37.39	1900	457	-1443	480	298	-181
37.45	1646	246	-1399	448	231	-217
37.49	1562	438	-1124	537	342	-194
37.56	1670	279	-1391	298	281	-17
37.63	1392	559	-832	392	226	-166
37.67	1288	475	-813	441	384	-56
37.72	1134	431	-703	438	283	-154
37.79	610	217	-392	596	194	-401
37.83	1106	417	-689	569	304	-264
37.91	1178	214	-964	1161	205	-956
37.97	1008	490	-517	910	476	-434
38.04	1434	245	-1189	1377	204	-1172
38.11	1594	1656	61	310	1618	1308
38.17	1724	1745	20	254	1723	1468
38.22	440	475	35	379	384	5
38.30	694	422	-272	234	84	-150
38.37	299	192	-107	260	181	-78
38.47	285	473	187	265	374	109
38.54	342	147	-195	313	104	-208
38.61	380	86	-293	338	78	-259
38.66	431	108	-323	395	96	-298
38.71	1373	92	-1281	375	80	-295
38.79	1144	48	-1095	456	44	-412
38.83	1280	58	-1222	1193	50	-1142
38.86	1312	98	-1213	1286	86	-1200
38.92	1182	89	-1092	1158	79	-1079
38.97	1305	100	-1204	1303	84	-1218
39.05	1185	88	-1097	287	79	-207
39.10	316	94	-222	288	83	-204
39.15	299	144	-155	253	128	-125
39.18	563	228	-334	298	207	-90
39.24	249	208	-41	249	112	-137

39.35	439	112	-327	438	107	-330
39.42	573	91	-481	569	85	-483
39.49	600	282	-317	551	235	-315

The following sections are in Mill Creek

38.22	443	450	6	394	449	55
38.28	496	760	263	341	711	370
38.34	444	476	32	421	460	38
38.44	436	466	30	373	444	71
38.52	331	425	93	317	390	72
38.60	368	382	14	354	363	8
38.64	296	297	0	291	295	4
38.69	327	328	0	311	310	0
38.77	397	394	-2	379	375	-4
38.83	546	531	-15	530	513	-16
38.91	493	484	-9	453	436	-16
38.96	430	410	-20	423	401	-21
39.07	510	500	-9	488	483	-5
39.19	601	602	1	576	573	-2
39.27	641	641	0	603	539	-63
39.36	740	737	-2	703	442	-260
39.43	919	916	-2	847	386	-461
39.51	937	890	-47	844	212	-631
39.56	879	865	-13	663	274	-389
39.63	461	460	-1	450	385	-64
39.68	324	324	0	324	324	0
39.76	219	219	0	219	219	0
39.83	160	160	0	160	160	0
39.91	379	379	0	379	379	0
40.00	630	629	-1	577	451	-125

Long-Term Changes in Floodplain Area - Floodplain areas were computed by integrating the floodplain width with channel length. Such areas were obtained for the incremental channel length of one half-mile covering cases 7, 8, 9, and 10. Floodplain areas for cases 7 and 8 pertaining to the 100-yr flood are compared as shown in Fig. 24; those for cases 9 and 10 pertaining to the 50-yr flood are compared as shown in Fig. 25. Numerical values of the areas are summarized in Table 6. It can be seen from these comparisons that the floodplain areas are generally smaller along the Santa Ana River with the presence of the dam. Floodplain area for Mill Creek is basically unaffected by the dam. The reduction in floodplain area for Santa Ana River is attributed to the lower flood discharges and greater channel-bed erosion associated with the presence of the dam.

Table 6. Long-term changes in floodplain area related to Seven Oaks Dam

Half mile reach starting river miles	Floodplain area for 100-yr flood acres			Floodplain area for 50-yr flood acres		
	Without dam	With dam	Difference	Without dam	With dam	Difference
30.0	141.0	123.3	-17.7	126.8	95.6	-31.2
30.5	115.8	100.3	-15.5	111.8	98.9	-12.9
31.0	82.6	64.7	-17.9	71.7	61.0	-10.7
31.5	88.6	68.1	-20.5	80.3	57.9	-22.4
32.0	106.7	80.9	-25.8	68.9	55.4	-13.5
32.5	128.3	85.1	-43.2	40.1	57.2	-17.1
33.0	59.3	47.7	-11.6	52.5	41.5	-11.0
33.5	93.0	29.2	-63.8	63.4	19.2	-44.2
34.0	119.2	66.7	-52.5	60.2	17.4	-42.8
34.5	188.5	80.1	-108.4	115.4	41.9	-73.5
35.0	106.0	19.4	-86.6	38.4	16.4	-22.0
35.5	75.8	16.9	-58.9	25.3	11.6	-13.7
36.0	68.7	16.3	-52.4	47.5	13.2	-34.3
36.5	204.3	75.2	-129.1	83.5	13.2	-70.3
37.0	120.8	51.3	-69.5	66.2	20.8	-45.4
37.5	66.2	20.7	-45.5	38.2	15.8	-22.4
38.0	155.6	76.2	-79.4	19.5	32.0	12.5
38.5	25.2	25.2	0.0	43.3	4.7	-38.6
The following is for Mill Creek						
38.0	43.0	65.0	22.0	28.0	35.0	7.0

Comparison of Short-Term and Long-Term Changes in Floodplain Area - As Seven Oaks Dam reduces the flood discharge and detains the sediment load of the Santa Ana River, the

flood level and floodplain width in the downstream river channel are affected. The effects of the dam on the flood discharge occurs at the completion of the dam. However, the effects of the dam on channel-bed scour will develop over a long period of time. Because of this difference, the long-term changes in floodplain area are greater than the short-term changes. In other words, the changes in floodplain width and area grow with time.

It should also be pointed out that the Santa Ana River and Mill Creek would undergo gradual siltation under the natural conditions before the presence of the dam. In other words, the floodplain width and area would actually grow with time without the presence of the dam.

VII. POSSIBLE MITIGATION MEASURES

Impacts of the Seven Oaks Dam on the downstream river channel are attributed to the reductions of the flood discharge and sediment supply. In order to mitigate these impacts, two possible measures are recommended as outlined below.

Bypass Tunnel: The function of a bypass tunnel is to allow passage of flood discharge and sediment through the reservoir. Of course, the quantities of bypassing need to be selected for optimum results. The purpose of the Seven Oaks Dam is to reduce the peak discharge of major floods, namely the 100-yr flood and the standard project flood. Lesser floods that are not detrimental to downstream areas do not need to be attenuated by the reservoir. It is therefore possible to bypass lesser floods through the reservoir without sacrificing the function of the reservoir. Bypass tunnels have been installed on the San-Men Gorge Dam on the Yellow River in China. The effectiveness of this measure has already been established. The bypass flow will carry the sediment load to the downstream channel. This has the benefit of prolonging the life of the reservoir. The composition of sediment in such a scenario should be similar to natural sediment load. The details of the measure require careful studies.

Check Dams: In order to supply water and sediment to overbank areas of the channel, check dams may be installed along the main channel at selected locations. With this measure, flow and

sediment can be diverted to cover more habitat areas during lesser floods. These structures will most likely be outflanked and destroyed during major events. The design of this measure will require careful studies.

REFERENCES:

Chang, H. H., *Fluvial Processes in River Engineering*, John Wiley & Sons, 1988, 431pp.

Simons, Li & Associates, Inc., "Hydraulic Analysis and Overflow Study Report for Prado Dam, Riverside County, California", February 1987.

U.S. Army Corps of Engineers, Los Angeles District, "Santa Ana River, Design Memorandum No. 1', Volume 1 Seven Oaks Dam and Volume 7 Hydrology, August 1988.

LIST OF FIGURES

- Fig. 1. Map of Santa Ana River near Mentone Fan
- Fig. 2. Size distributions of bed sediment
- Fig. 3. Hydrograph of 100-yr flood for Santa Ana River below Mill Creek
- Fig. 4. Hydrographs for flood series in the 100-yr time span - before Seven Oaks Dam
- Fig. 5. Hydrographs for flood series in the 100-yr time span - after Seven Oaks Dam
- Fig. 6. Spatial variations in sediment delivery along the river reach during the flood series - before Seven Oaks Dam
- Fig. 7. Spatial variations in sediment delivery along the river reach during the flood series - after Seven Oaks Dam
- Fig. 8. Short-term changes in 100-yr flood level along Santa Ana River and Mill Creek - before Seven Oaks Dam
- Fig. 9. Sort-term changes in 50-yr flood level along Santa Ana River and Mill Creek - before Seven Oaks Dam
- Fig. 10. Short-term changes in 100-yr flood level along Santa Ana River and Mill Creek - after Seven Oaks Dam
- Fig. 11. Short-term changes in 50-yr flood level along Santa Ana River and Mill Creek - after Seven Oaks Dam
- Fig. 12. Long-term changes in 100-yr flood level along Santa Ana River and Mill Creek - before Seven Oaks Dam
- Fig. 13. Long-term changes in 50-yr flood level along Santa Ana River and Mill Creek - before Seven Oaks Dam
- Fig. 14. Long-term changes in 100-yr flood level along Santa Ana River and Mill Creek - after Seven Oaks Dam
- Fig. 15. Long-term changes in 50-yr flood level along Santa Ana River and Mill Creek - after Seven Oaks Dam
- Fig. 16. Changes in channel-bed profile of Santa Ana River near Mill Creek confluence - after Seven Oaks Dam

Fig. 17. Changes in channel-bed profiles of Santa Ana River and Mill Creek near confluence - after Seven Oaks Dam

Fig. 18. Widths of 100-yr floodplain for conditions with and without the dam - short-term changes

Fig. 19. Widths of 50-yr floodplain for conditions with and without the dam - short-term changes

Fig. 20. Areas of 100-yr floodplain for conditions with and without the dam - short-term changes

Fig. 21. Areas of 50-yr floodplain for conditions with and without the dam - short-term changes

Fig. 22. Widths of 100-yr floodplain for conditions with and without the dam - long-term changes

Fig. 23. Widths of 50-yr floodplain for conditions with and without the dam - long-term changes

Fig. 24. Areas of 100-yr floodplain for conditions with and without the dam - long-term changes

Fig. 25. Areas of 50-yr floodplain for conditions with and without the dam - long-term changes

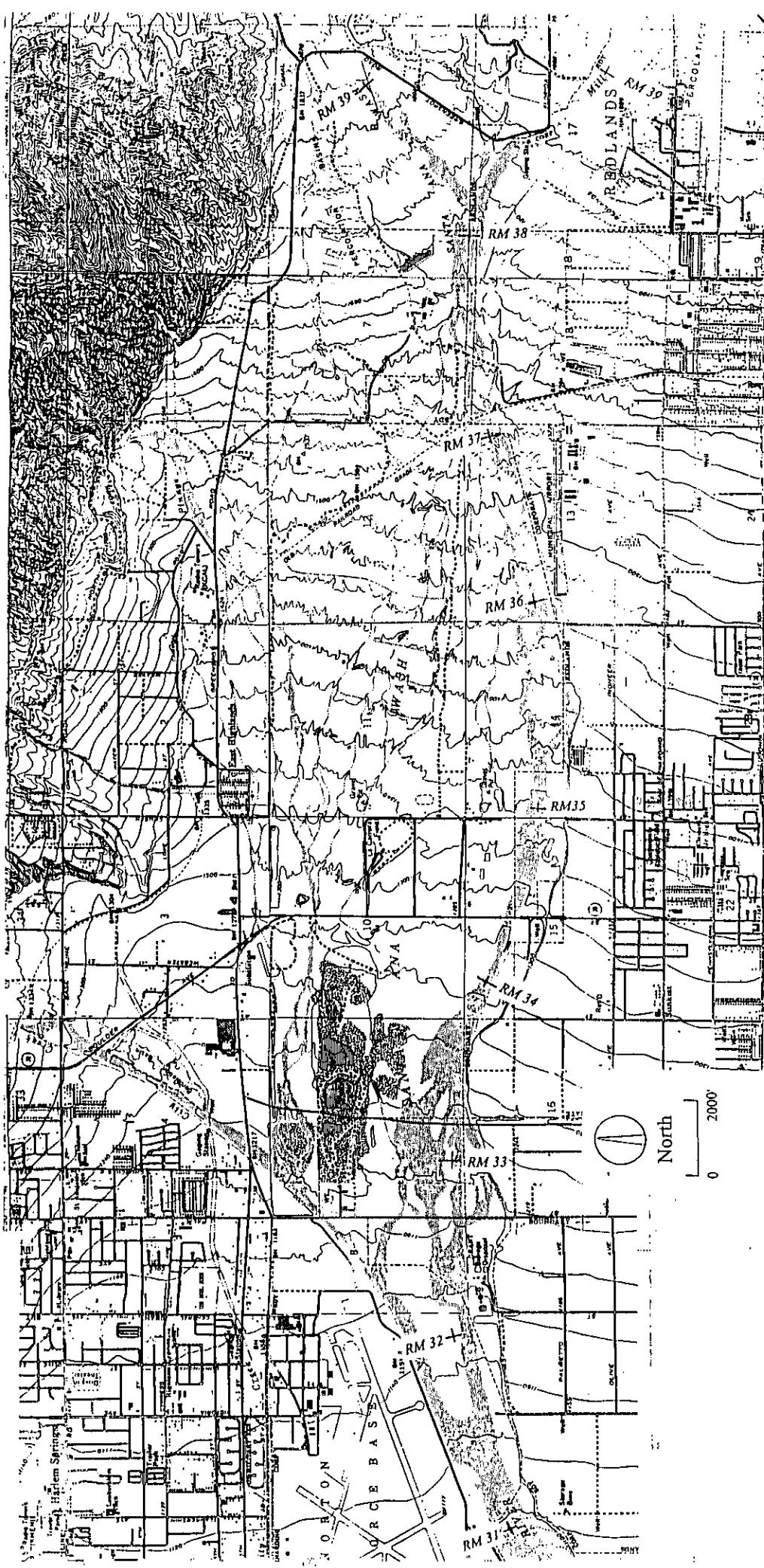


Fig. 1. Map of Santa Ana River near Mentone Fan

Santa Ana River
Grain Size Distributions

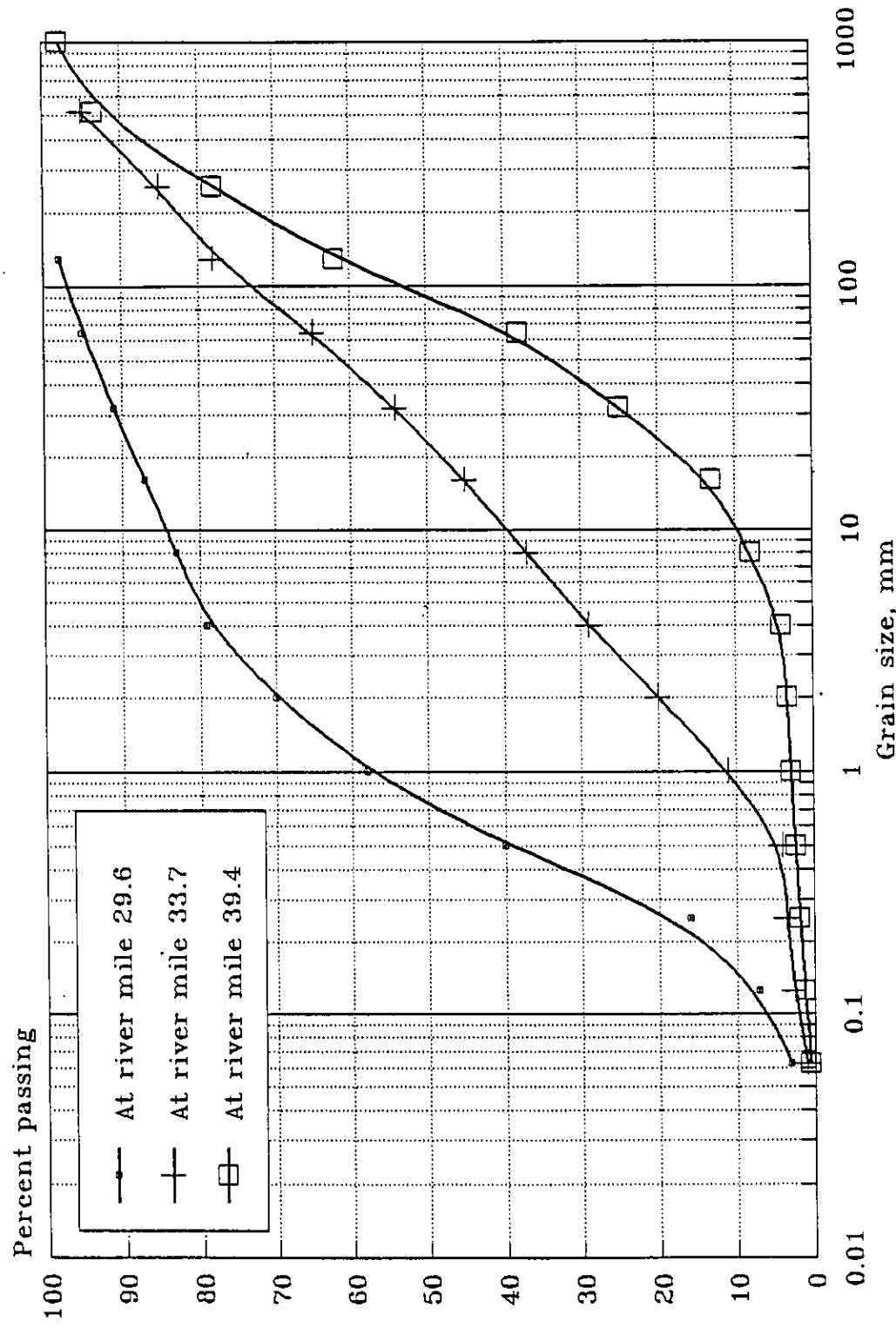


Fig. 2. Size distributions of bed sediment

Santa Ana River
Flood Hydrograph

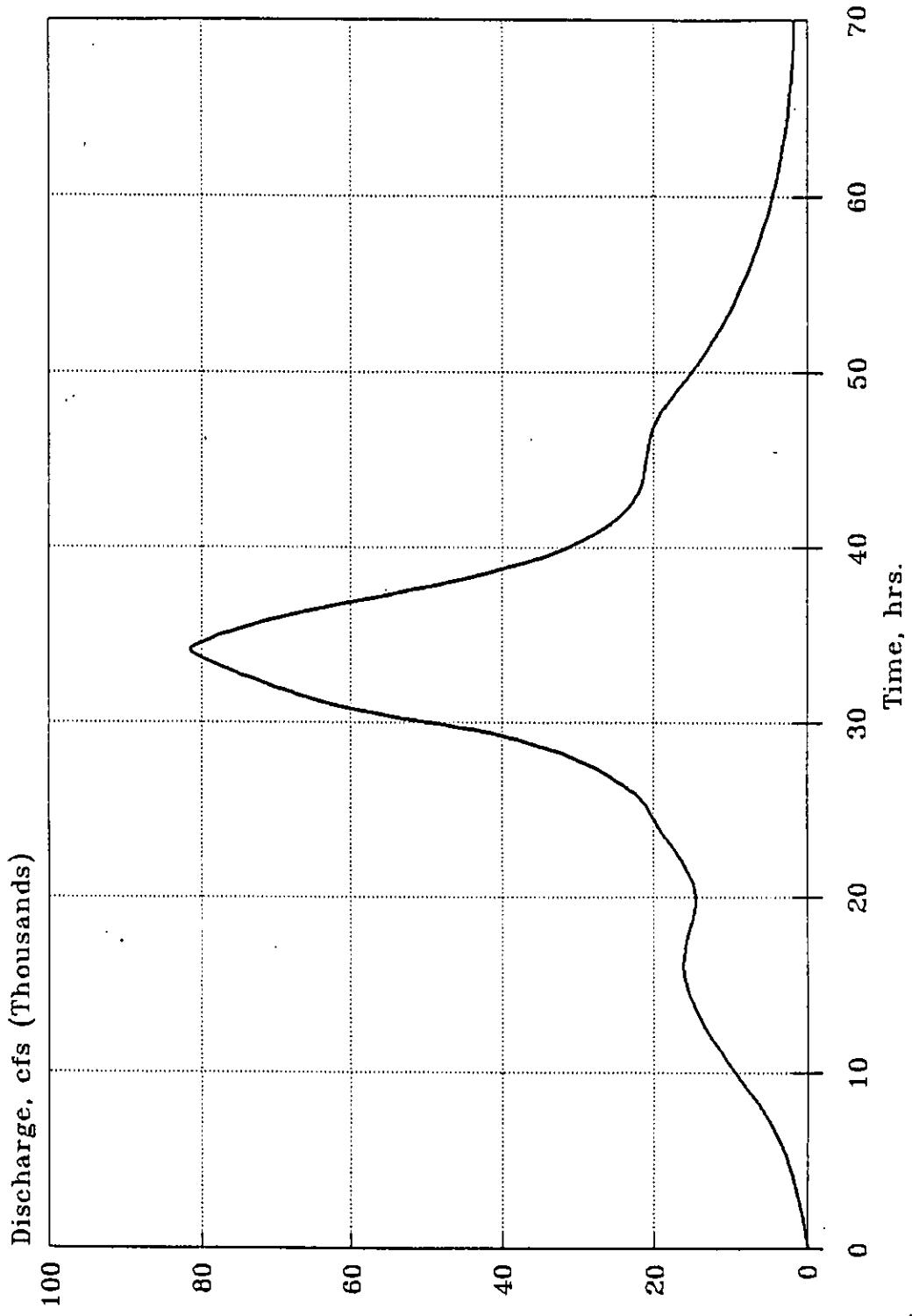


Fig. 3. Hydrograph of 100-yr flood for Santa Ana River below Mill Creek

Santa Ana River
Flood series in 100-yr time span

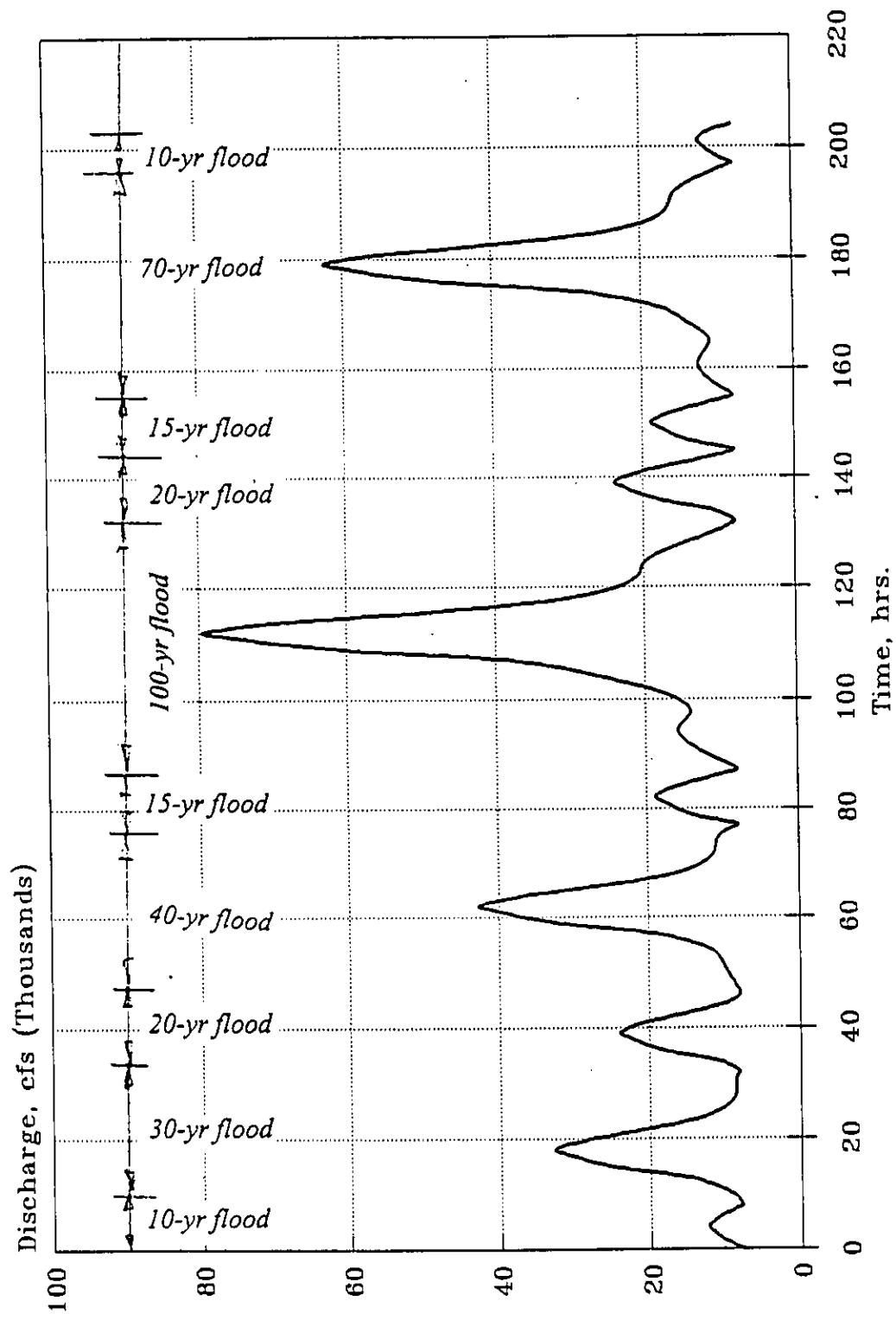


Fig.4. Hydrographs for flood series in the 100-yr time span
- before Seven Oaks Dam

Santa Ana River below Mill Creek
Flood Series in 100 Years

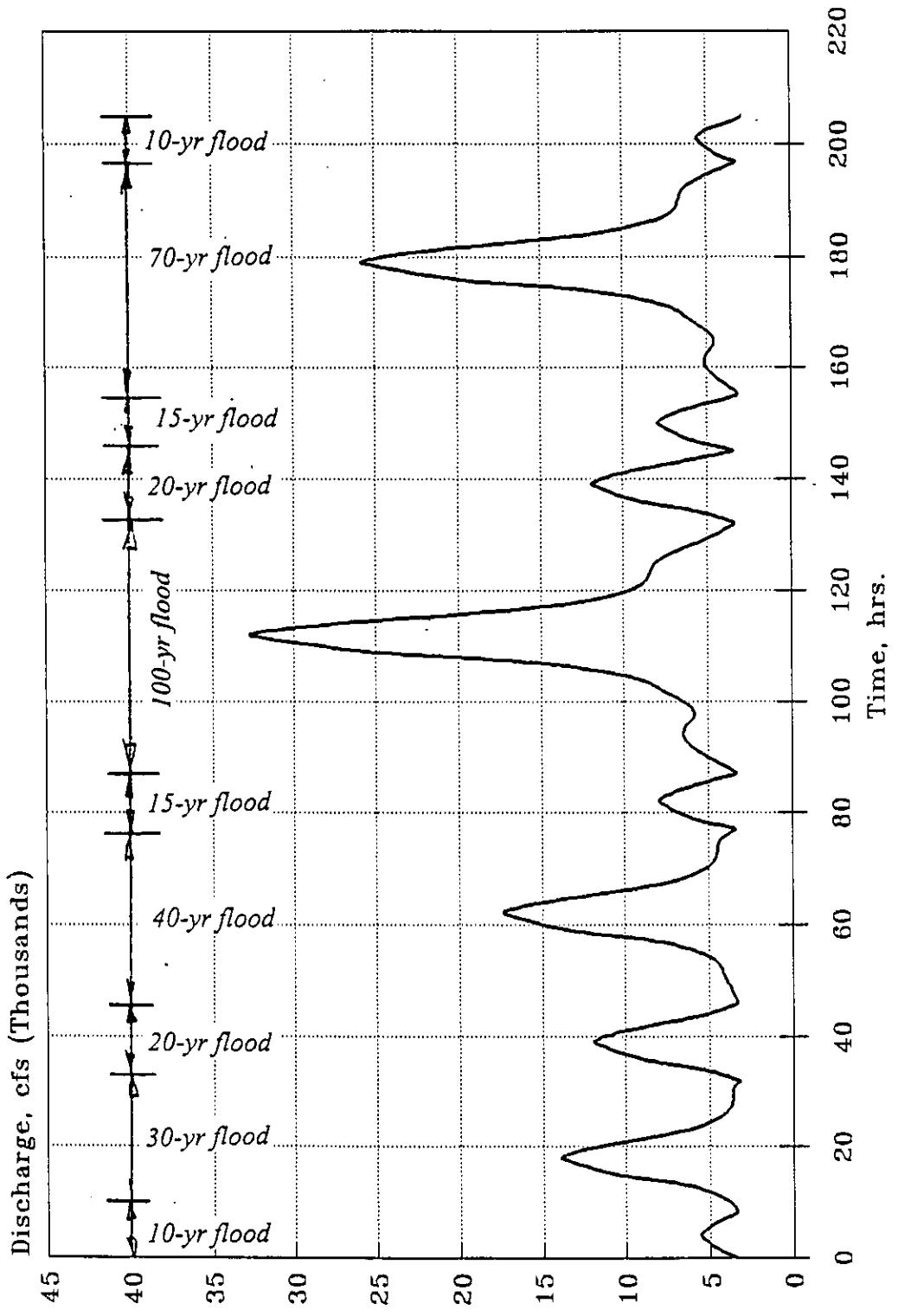


Fig. 5. Hydrographs for flood series in the 100-yr time span
- after Seven Oaks Dam

Santa Ana River
 Spatial Variations in Sediment Delivery
 During 100-yr flood series

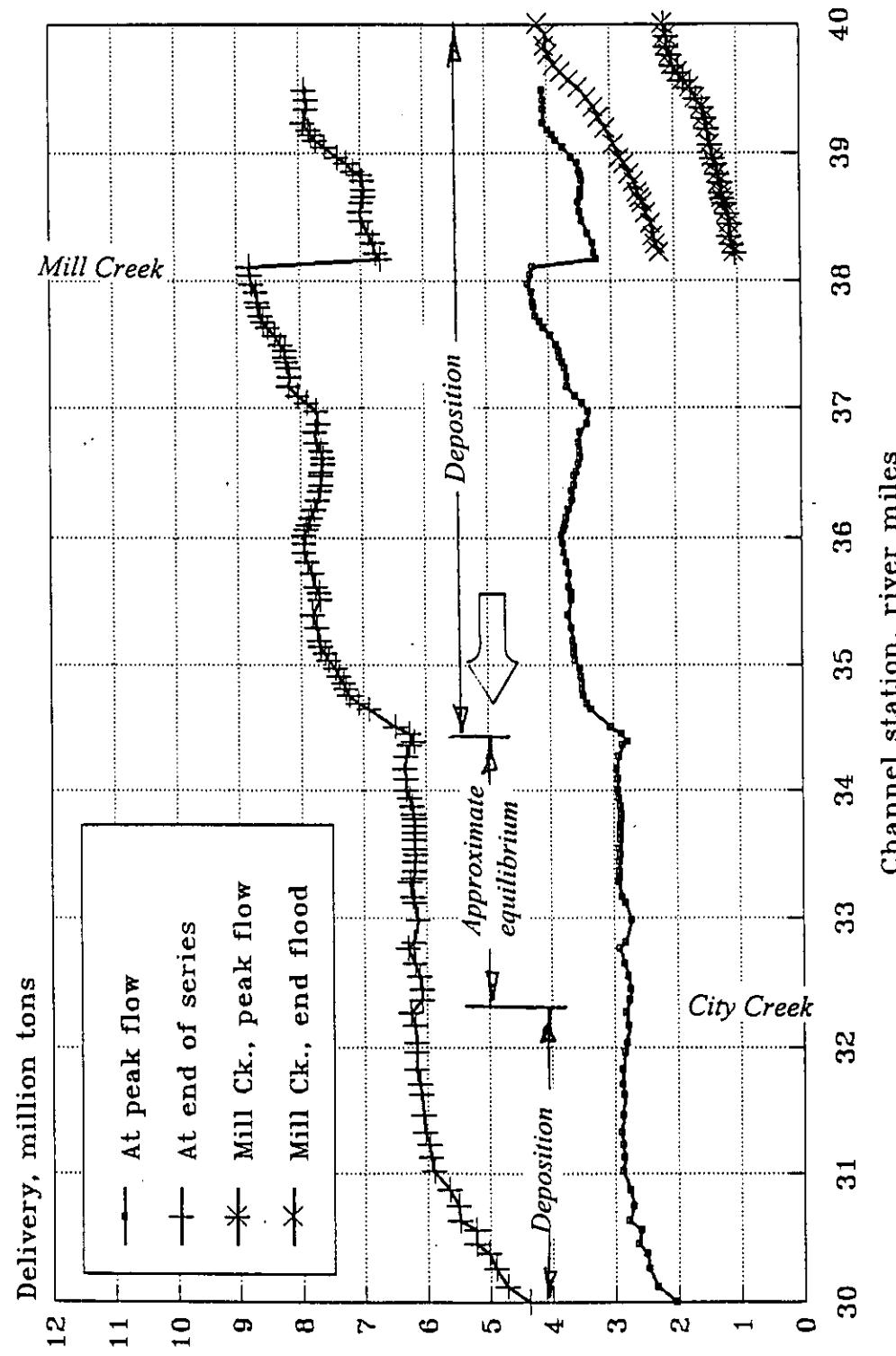


Fig. 6. Spatial variations in sediment delivery along the river reach during the flood series - before Seven Oaks Dam

Santa Ana River
 Spatial Variations in Sediment Delivery
 During 100-yr flood series

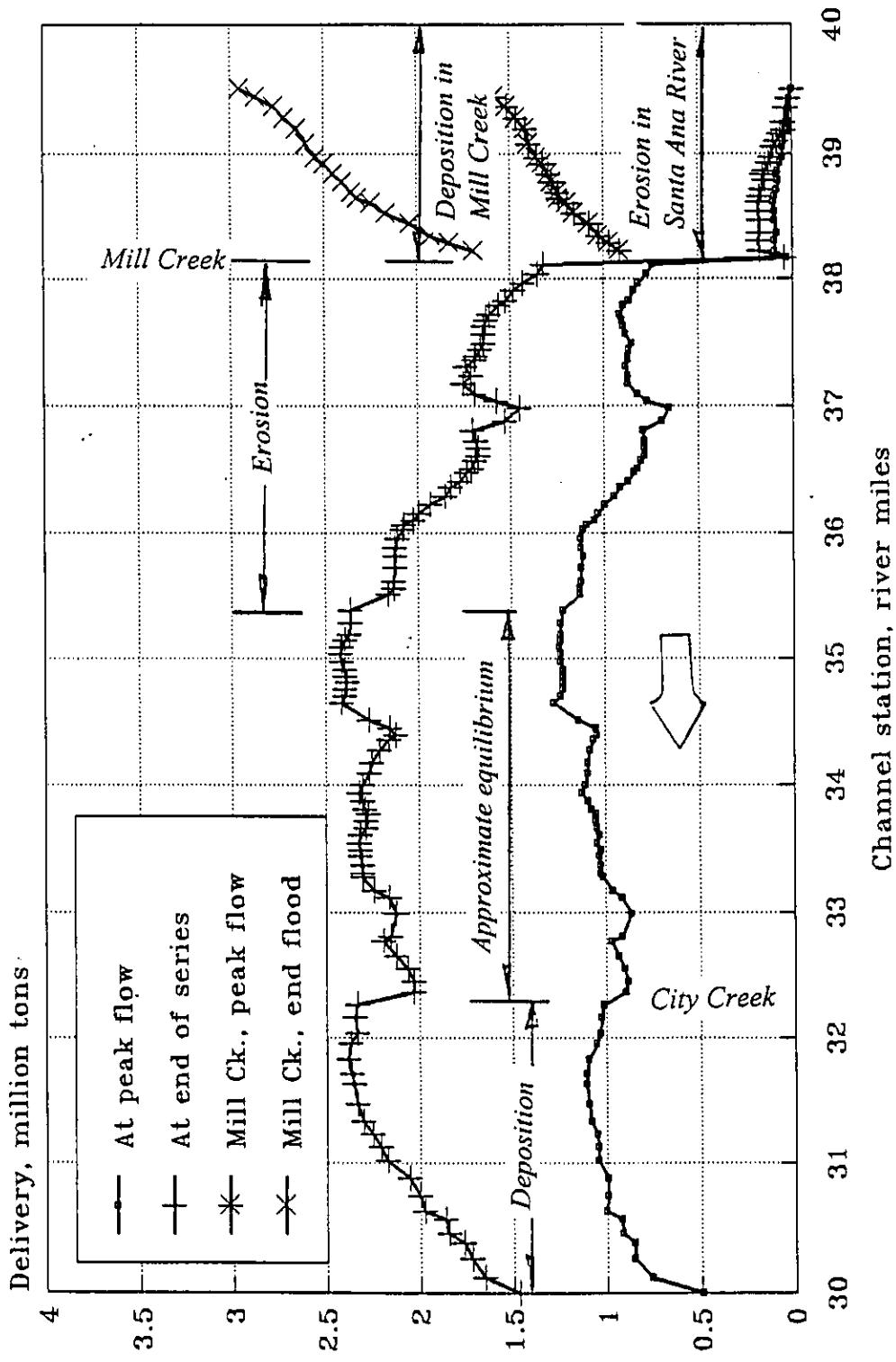


Fig. 7. Spatial variations in sediment delivery along the river reach
 during the flood series - after Seven Oaks Dam

Santa Ana River/Mill Creek
Changes in 100-yr Flood Level

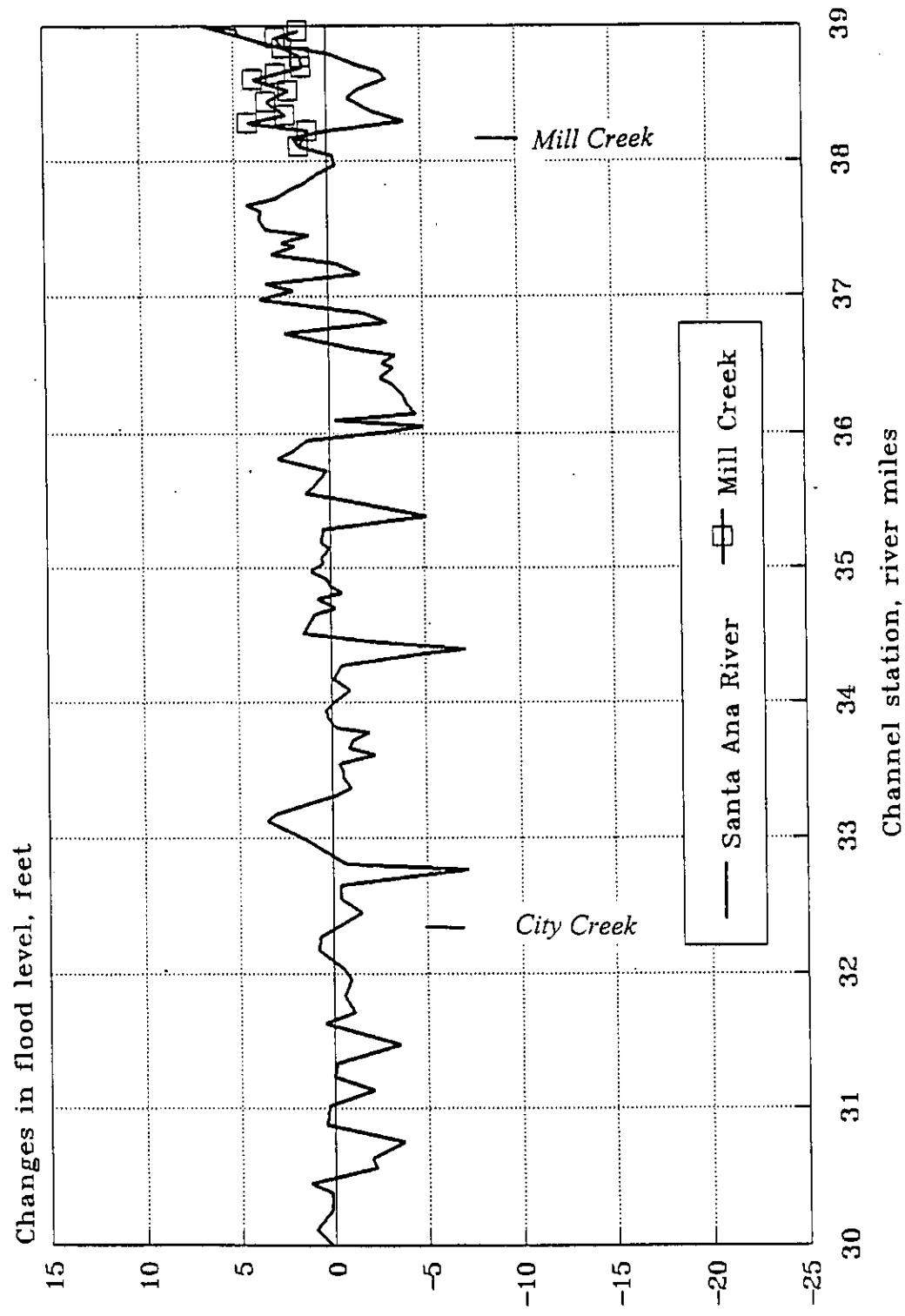


Fig. 8. Short-term changes in 100-yr flood level along Santa Ana River and Mill Creek - before Seven Oaks Dam

Santa Ana River/Mill Creek
Changes in 50-yr Flood Level

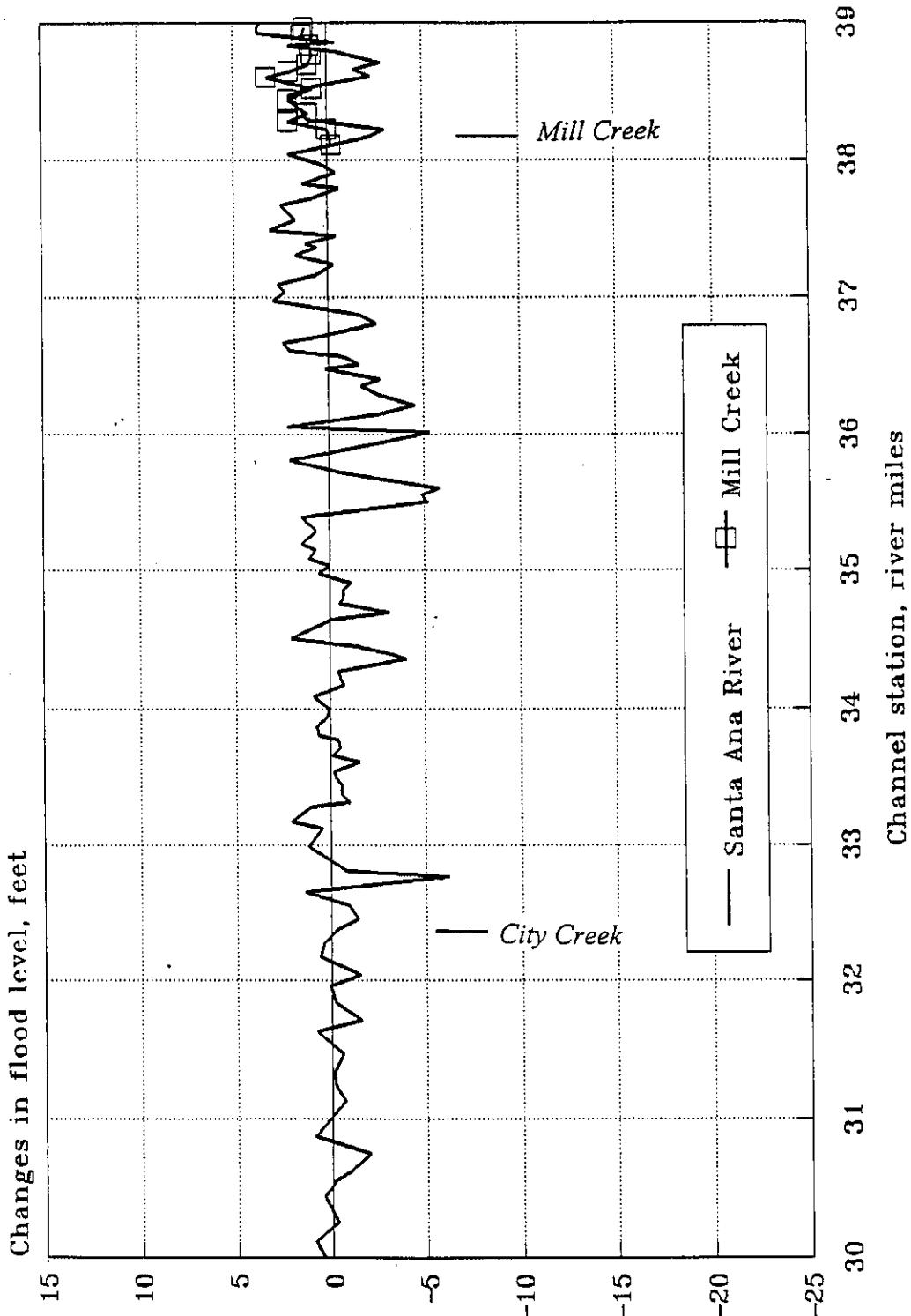


Fig. 9. Short-term changes in 50-yr flood level along Santa Ana River and Mill Creek - before Seven Oaks Dam

Santa Ana River/Mill Creek
Changes in 100-yr Flood Level

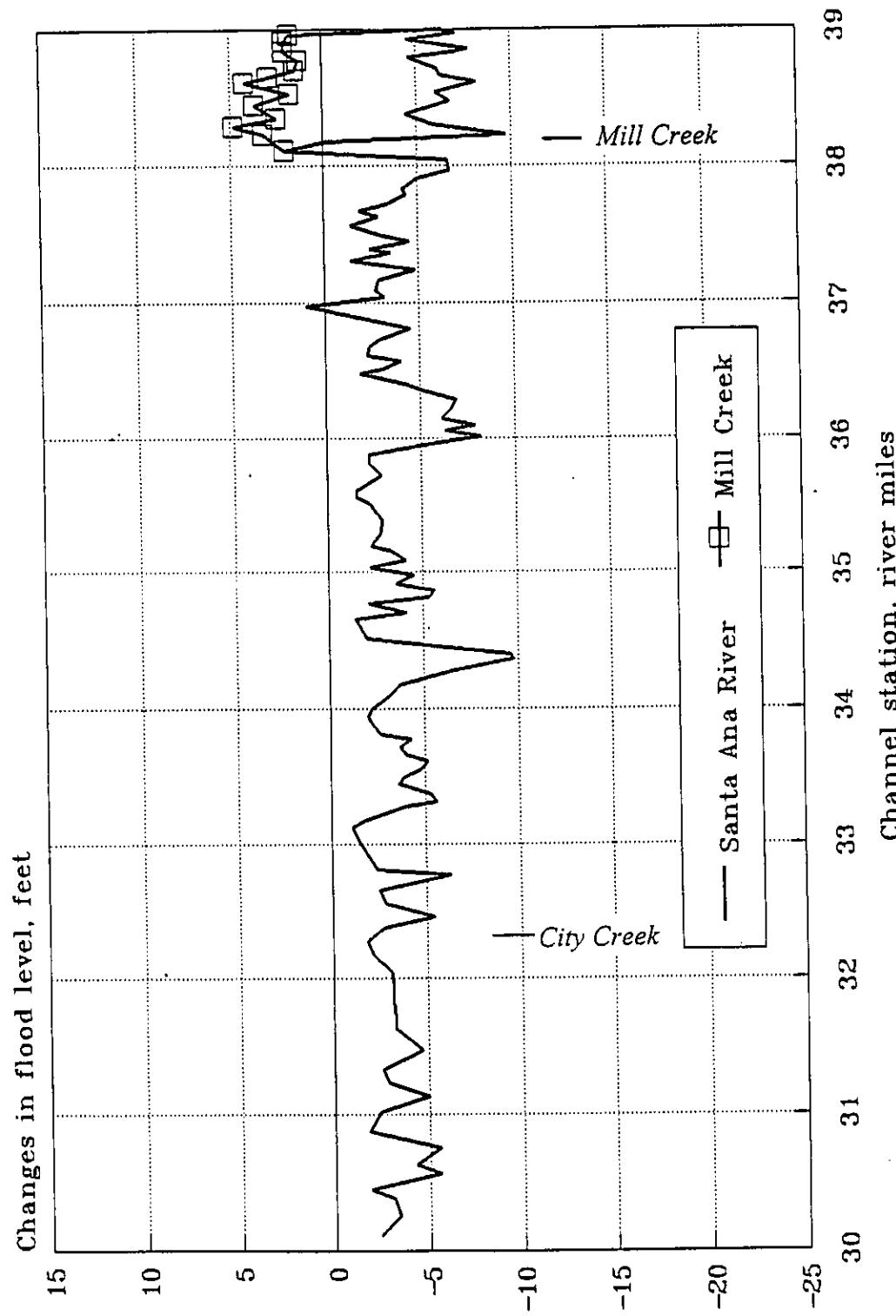


Fig. 10. Short-term changes in 100-yr flood level along Santa Ana River and Mill Creek - after Seven Oaks Dam

Santa Ana River/Mill Creek
Changes in 50-yr Flood Level

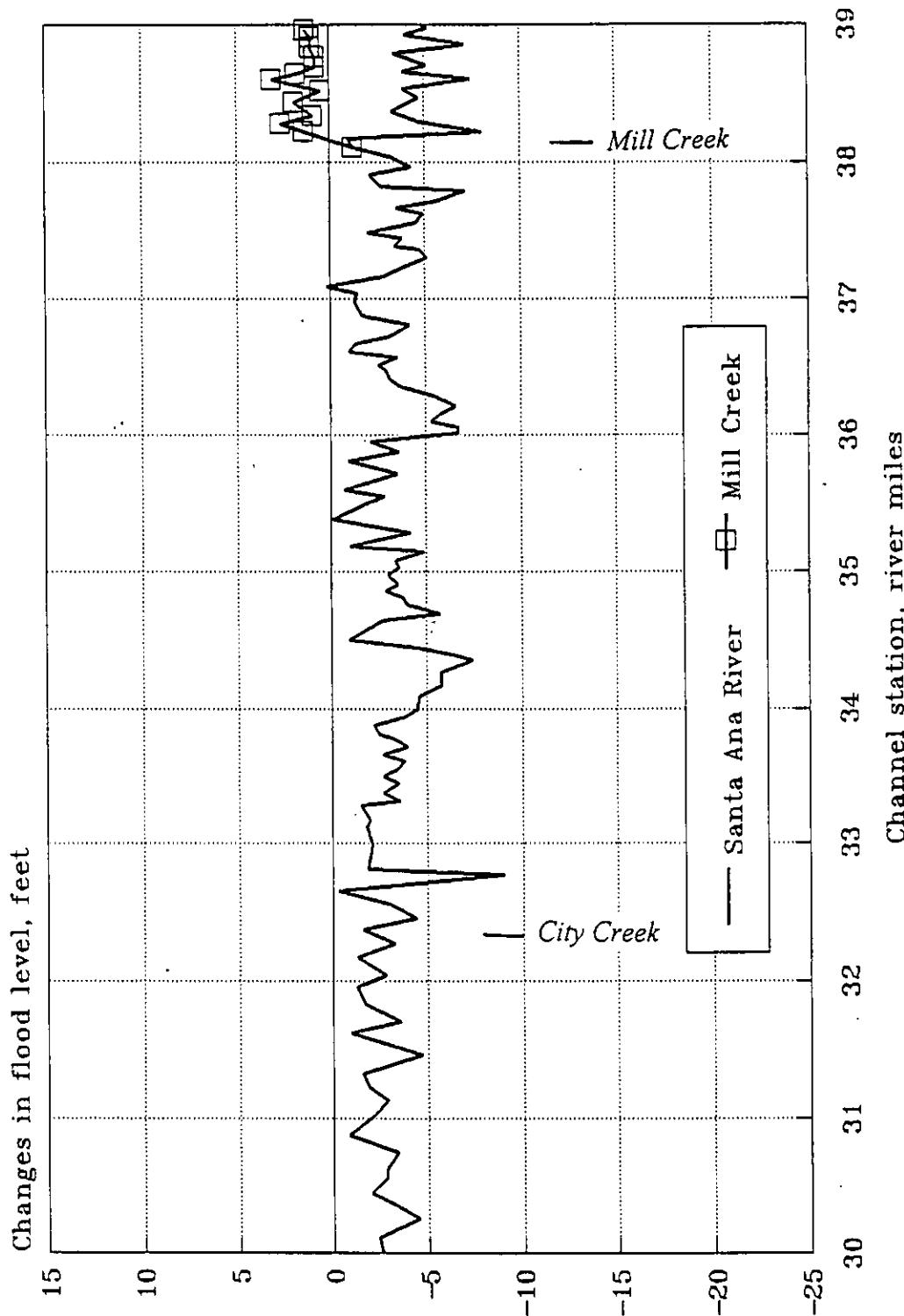


Fig. 11. Short-term changes in 50-yr flood level along Santa Ana River and Mill Creek - after Seven Oaks Dam

Santa Ana River/Mill Creek
Changes in 100-yr Flood Level
In 100 Years

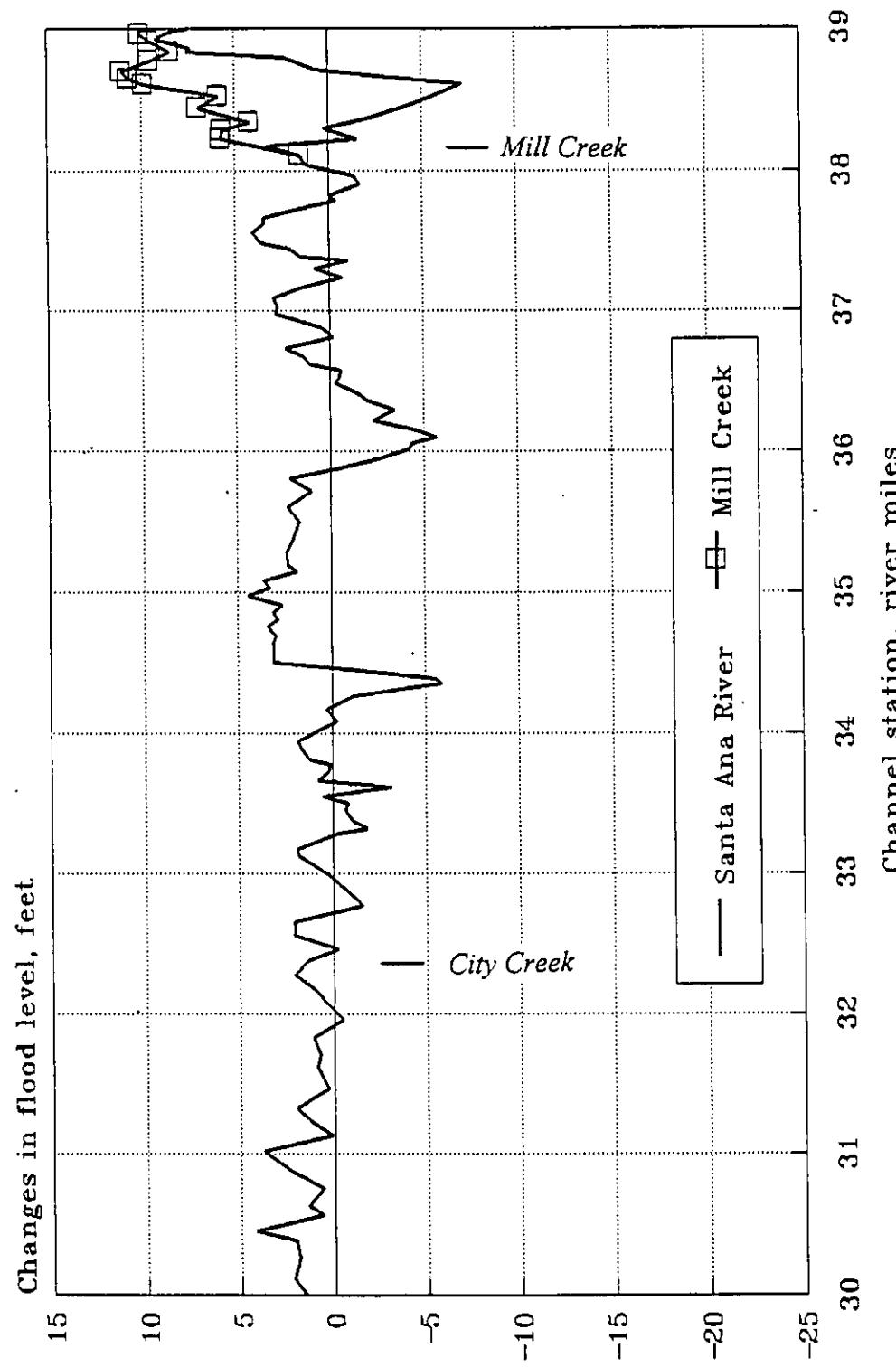


Fig. 12. Long-term changes in 100-yr flood level along Santa Ana River and Mill Creek - before Seven Oaks Dam

Santa Ana River/Mill Creek
Changes in 50-yr Flood Level
In 100 Years

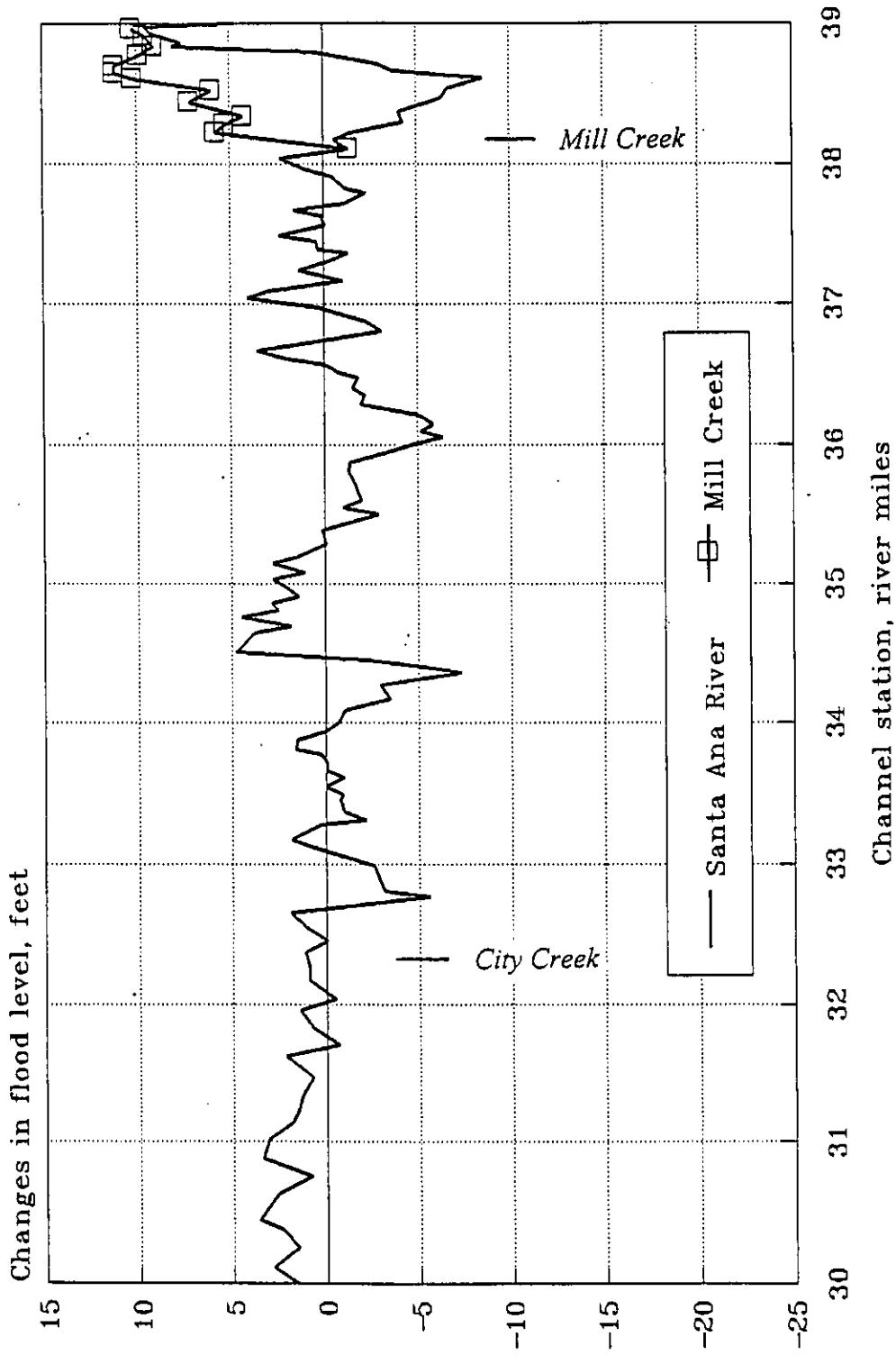


Fig. 13. Long-term changes in 50-yr flood level along Santa Ana River and Mill Creek -before Seven Oaks Dam

Santa Ana River/Mill Creek
Changes in 100-yr Flood Level
In 100 Years

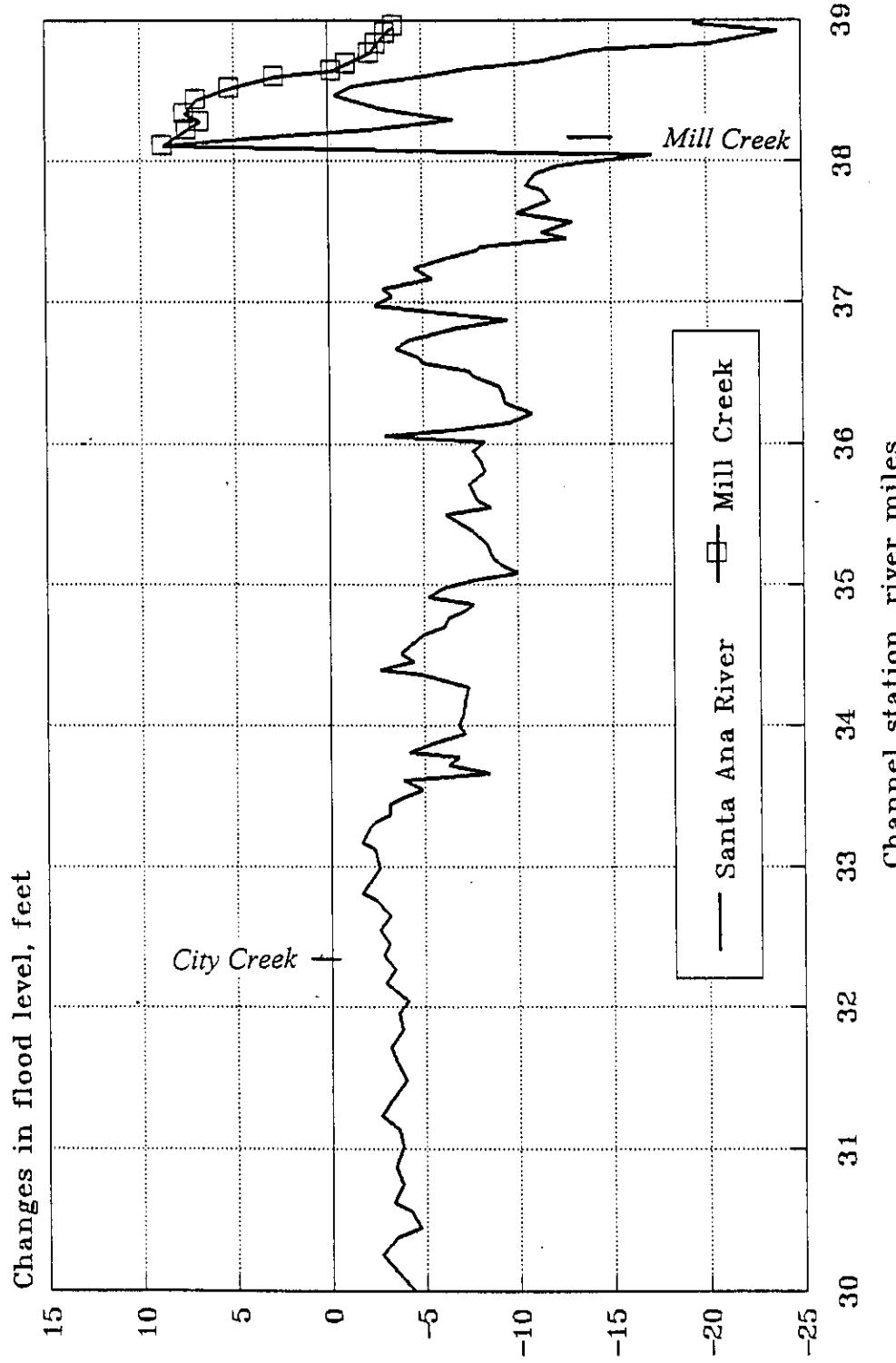


Fig. 14. Long-term changes in 100-yr flood level along Santa Ana River and Mill Creek - after Seven Oaks Dam

Santa Ana River/Mill Creek
Changes in 50-yr Flood Level
In 100 Years

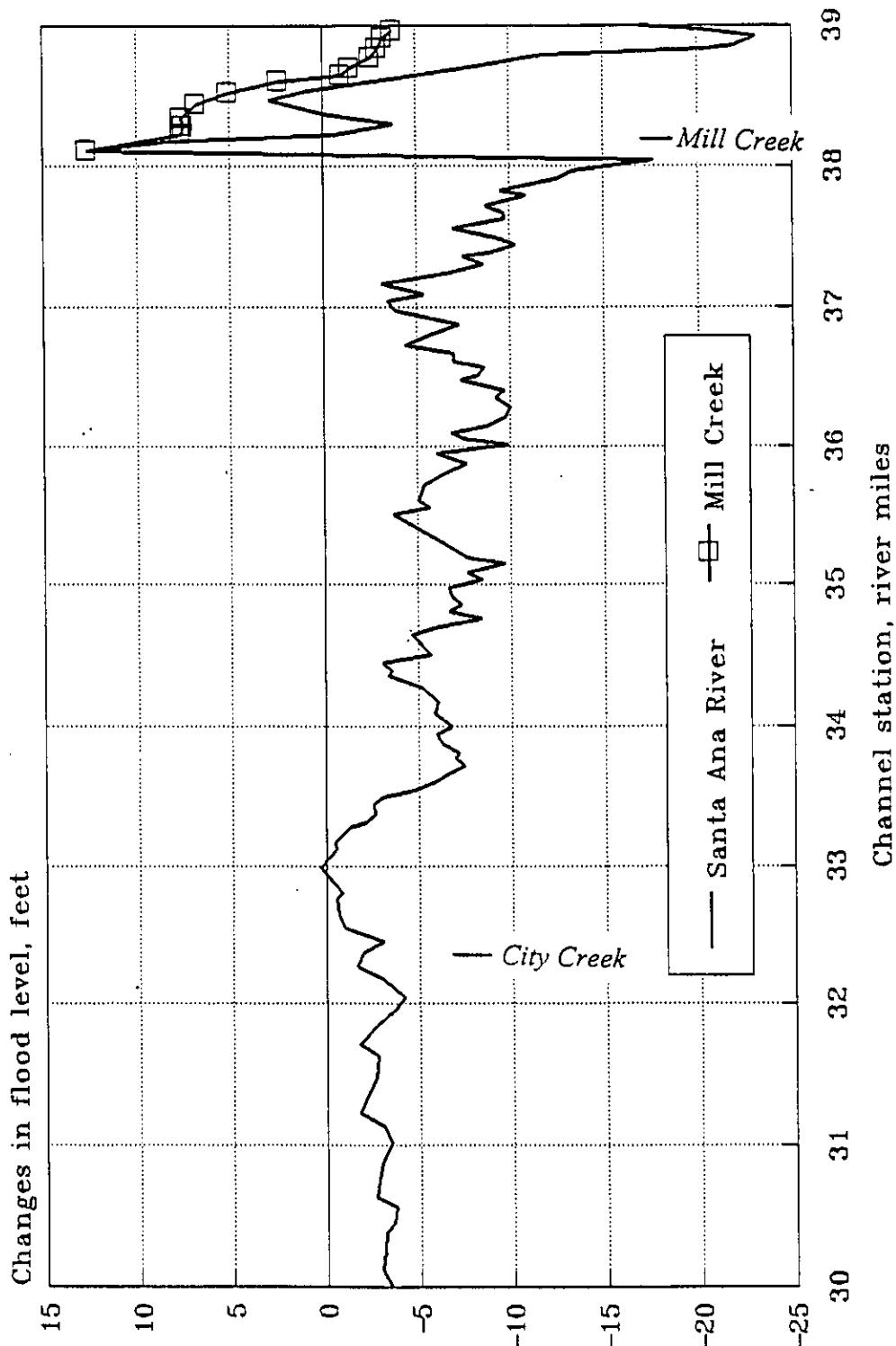


Fig. 15. Long-term changes in 50-yr flood level along Santa Ana River and Mill Creek - after Seven Oaks Dam

Santa Ana River
Water-Surface and Channel-Bed Profiles
During Flood Series

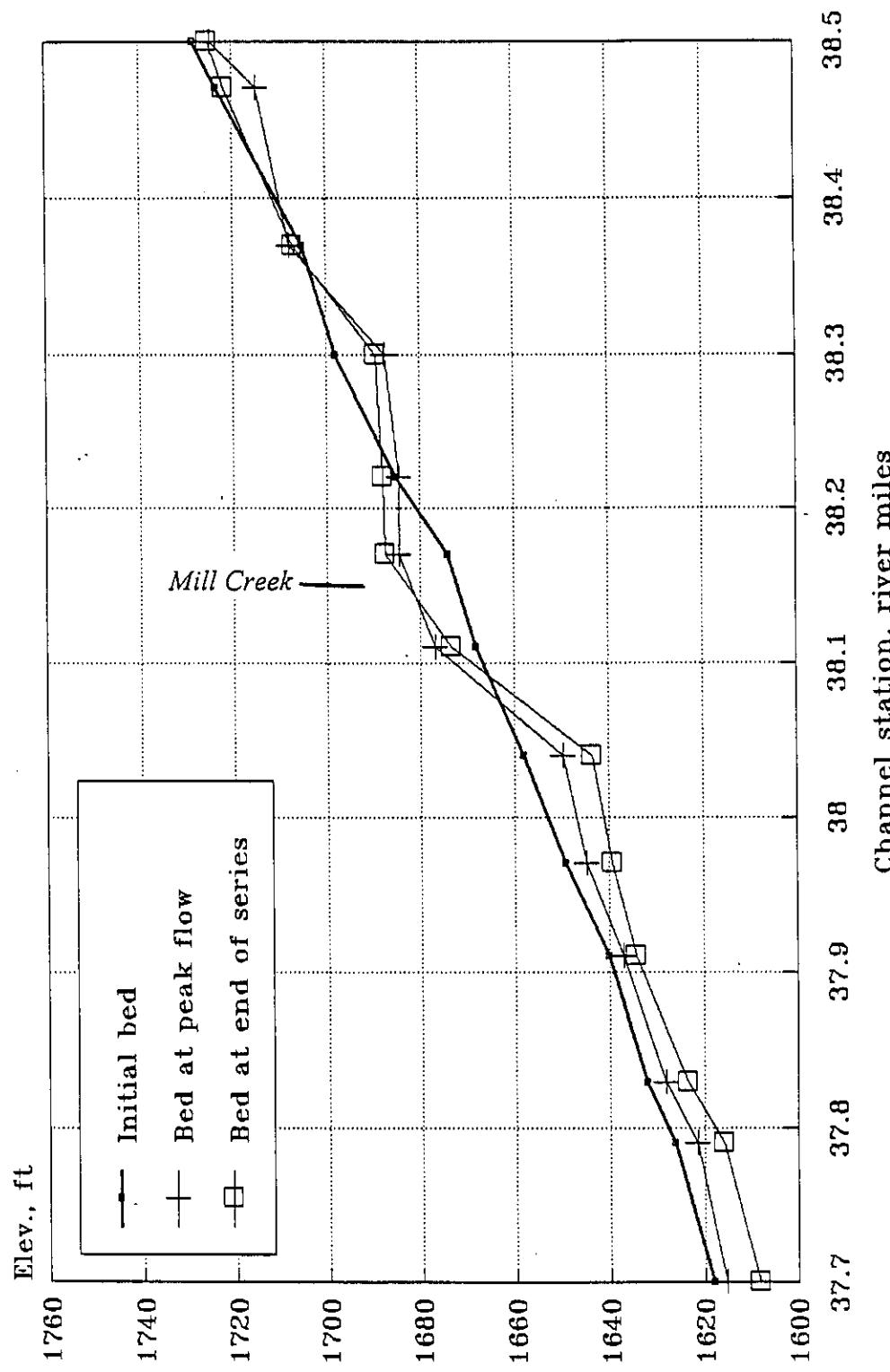
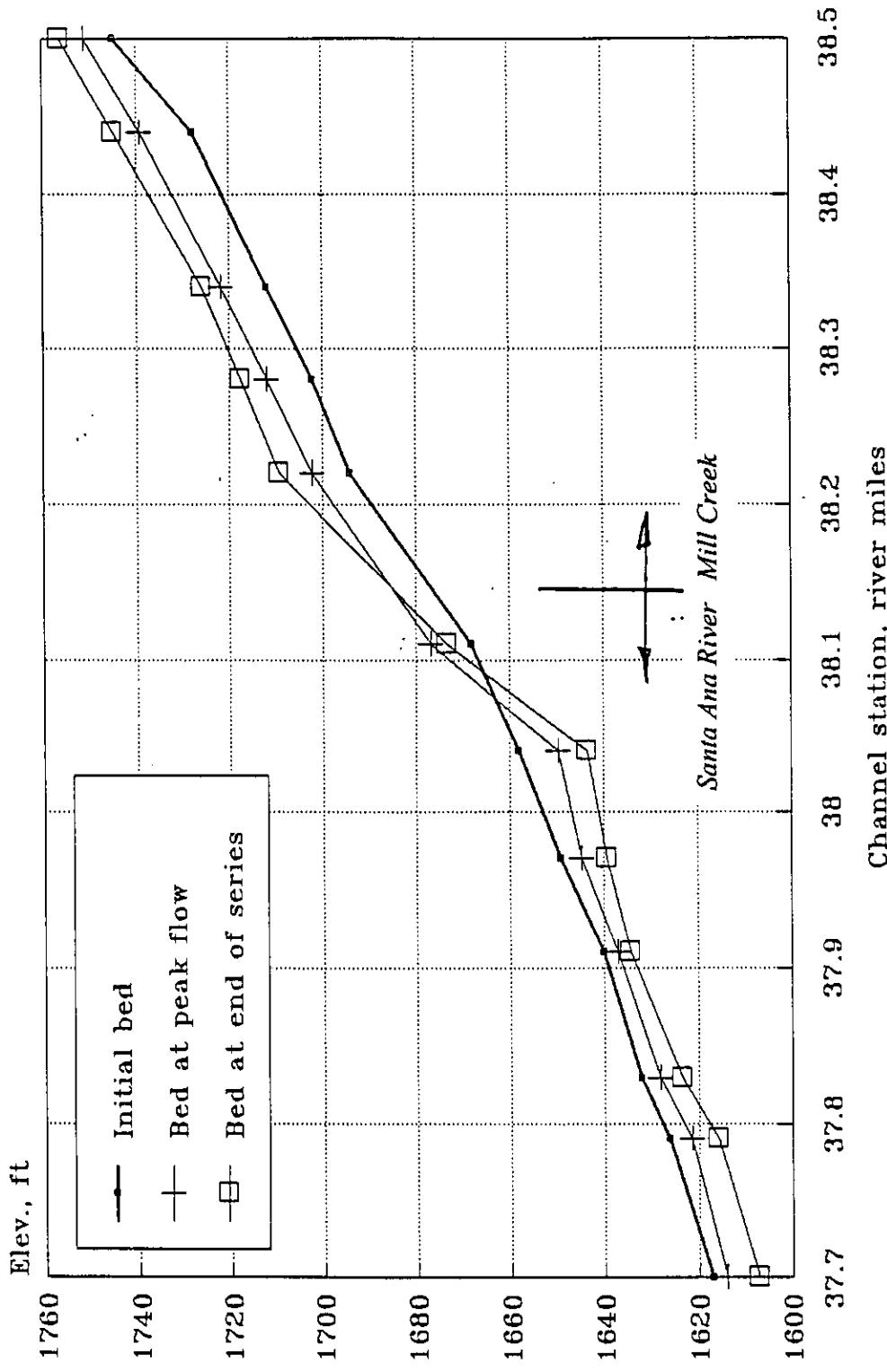


Fig. 16. Changes in channel-bed profile of Santa Ana River near
Mill Creek confluence - after Seven Oaks Dam

Santa Ana River/Mill Creek
Water-Surface and Channel-Bed Profiles
During Flood Series



Channel station, river miles

Fig. 17. Changes in channel-bed profiles of Santa Ana River and Mill Creek near confluence - after Seven Oaks Dam

Santa Ana River/Mill Creek
Widths of 100-yr Floodplain

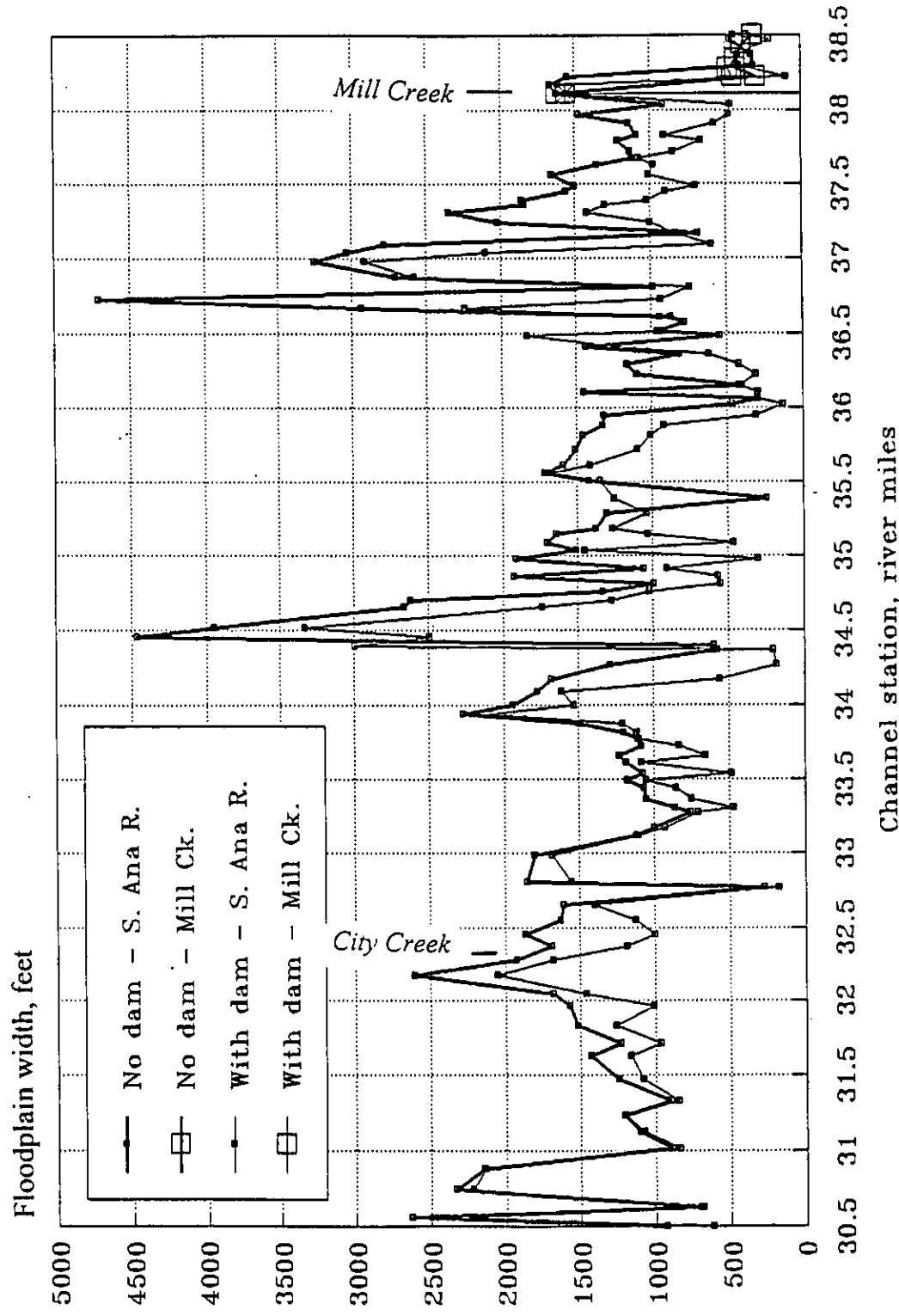


Fig. 18. Widths of 100-yr floodplain for conditions with and without the dam - short-term changes

Santa Ana River/Mill Creek
Widths of 50-yr Floodplain

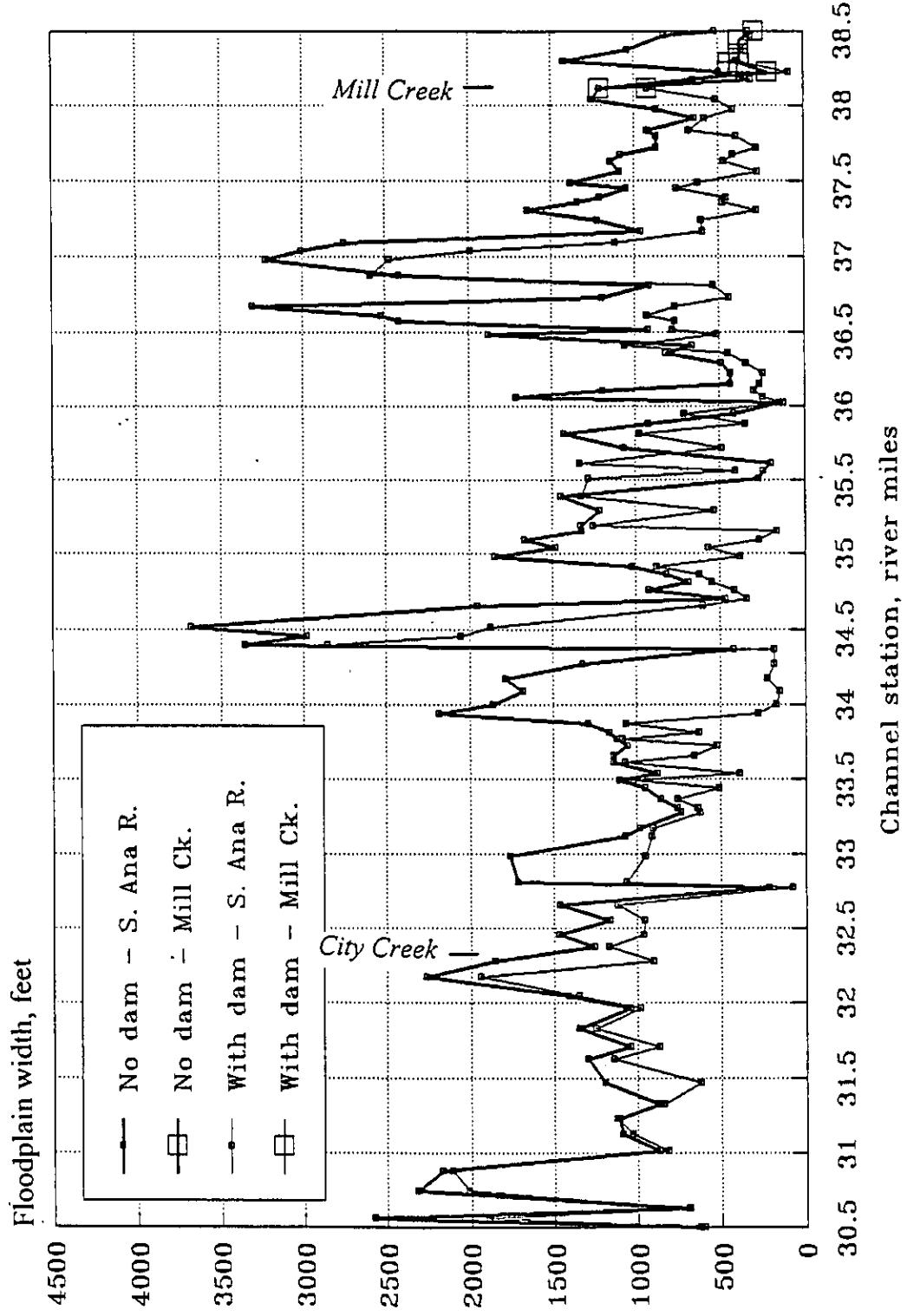


Fig. 19. Widths of 50-yr floodplain for conditions with and without the dam - short-term changes

Santa Ana River
 Floodplain Area per Half-Mile Reach
 for 100-yr Flood

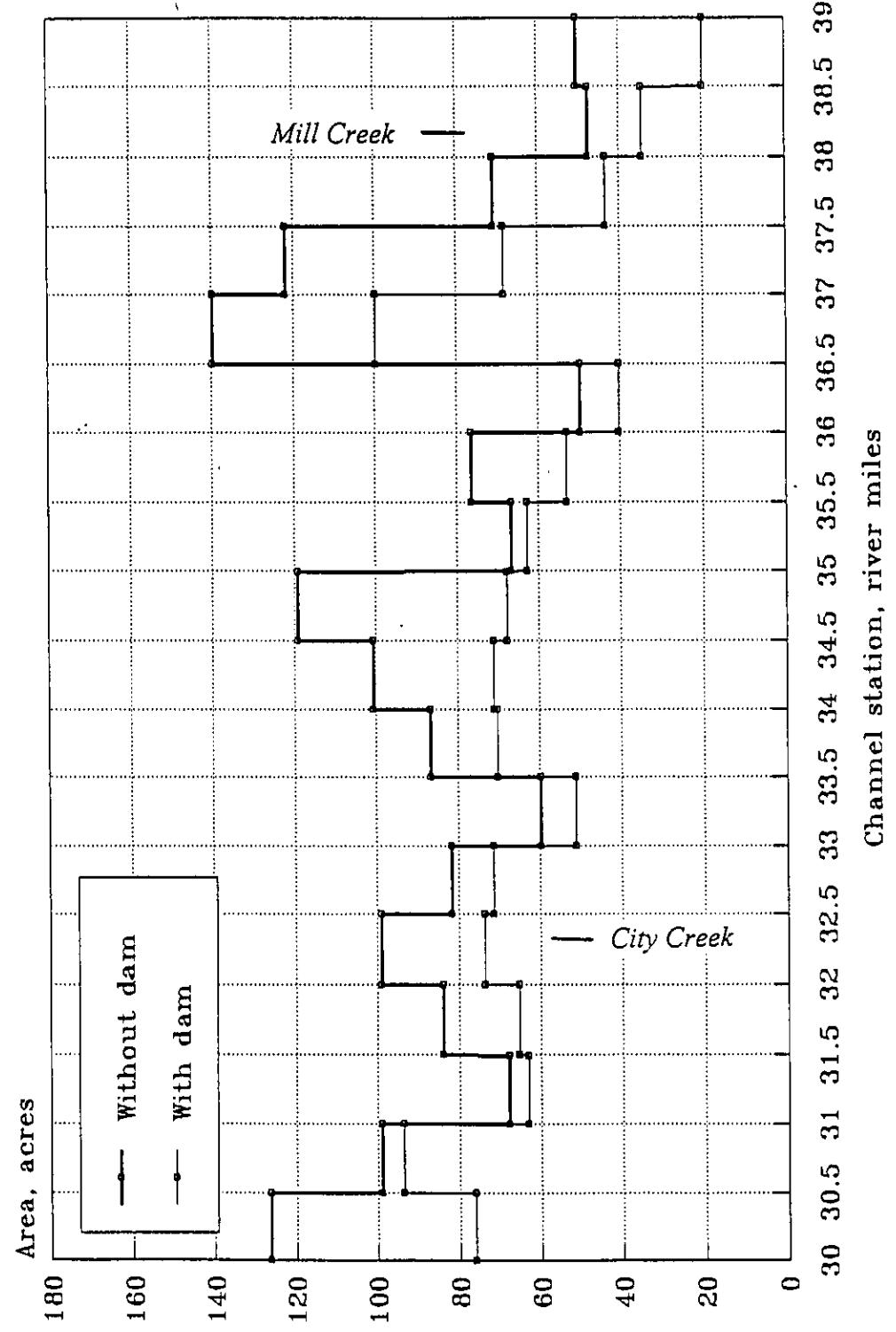


Fig. 20. Areas of 100-yr floodplain for conditions with
 and without the dam - short-term changes

Santa Ana River
 Floodplain Area per Half-Mile Reach
 for 50-yr Flood

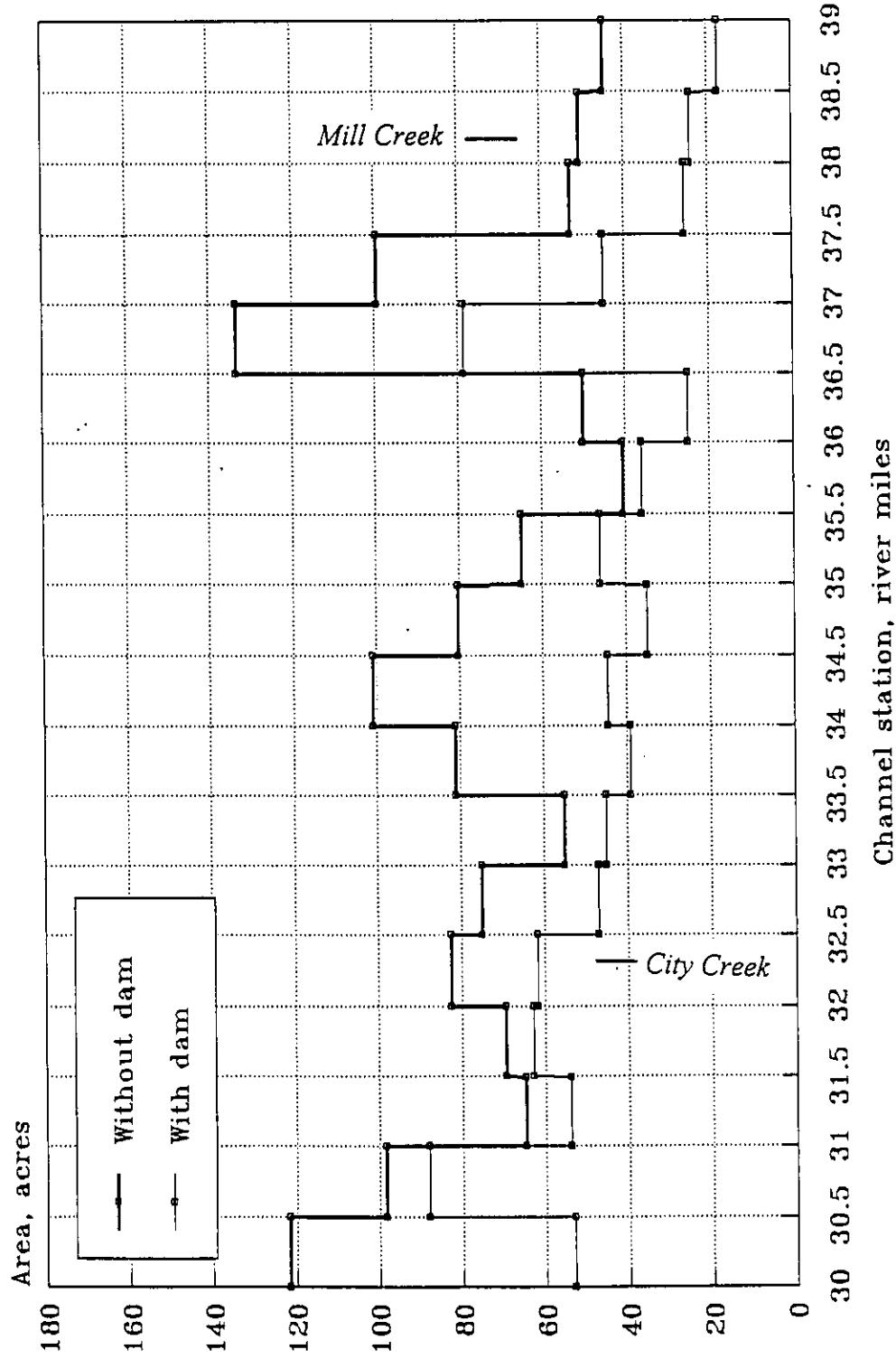


Fig. 21. Areas of 50-yr floodplain for conditions with
 and without the dam - short-term changes

Santa Ana River/Mill Creek
Widths of 100-yr Floodplain

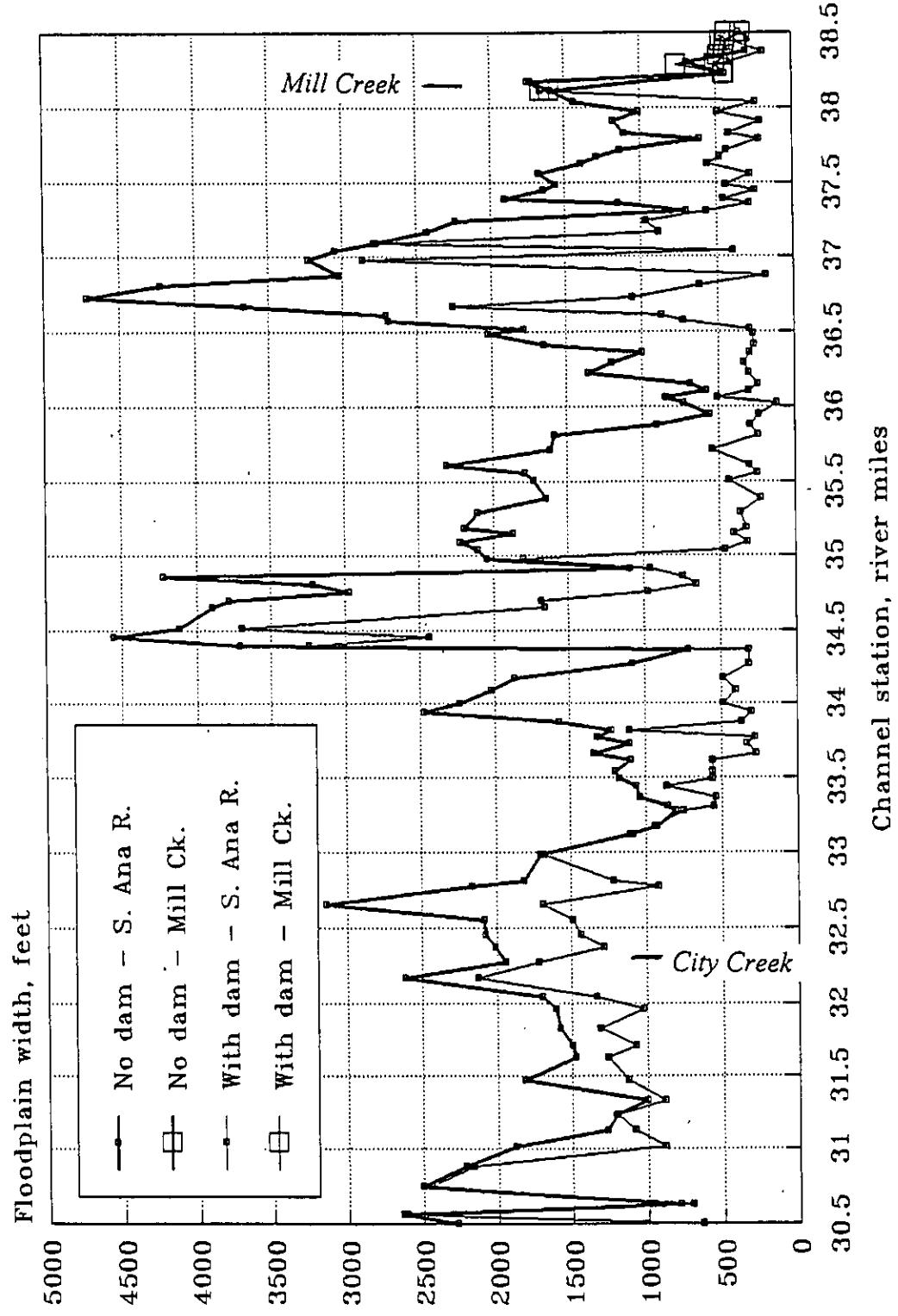


Fig. 22. Widths of 100-yr floodplain for conditions with and without the dam - long-term changes

Santa Ana River/Mill Creek
Widths of 50-yr Floodplain

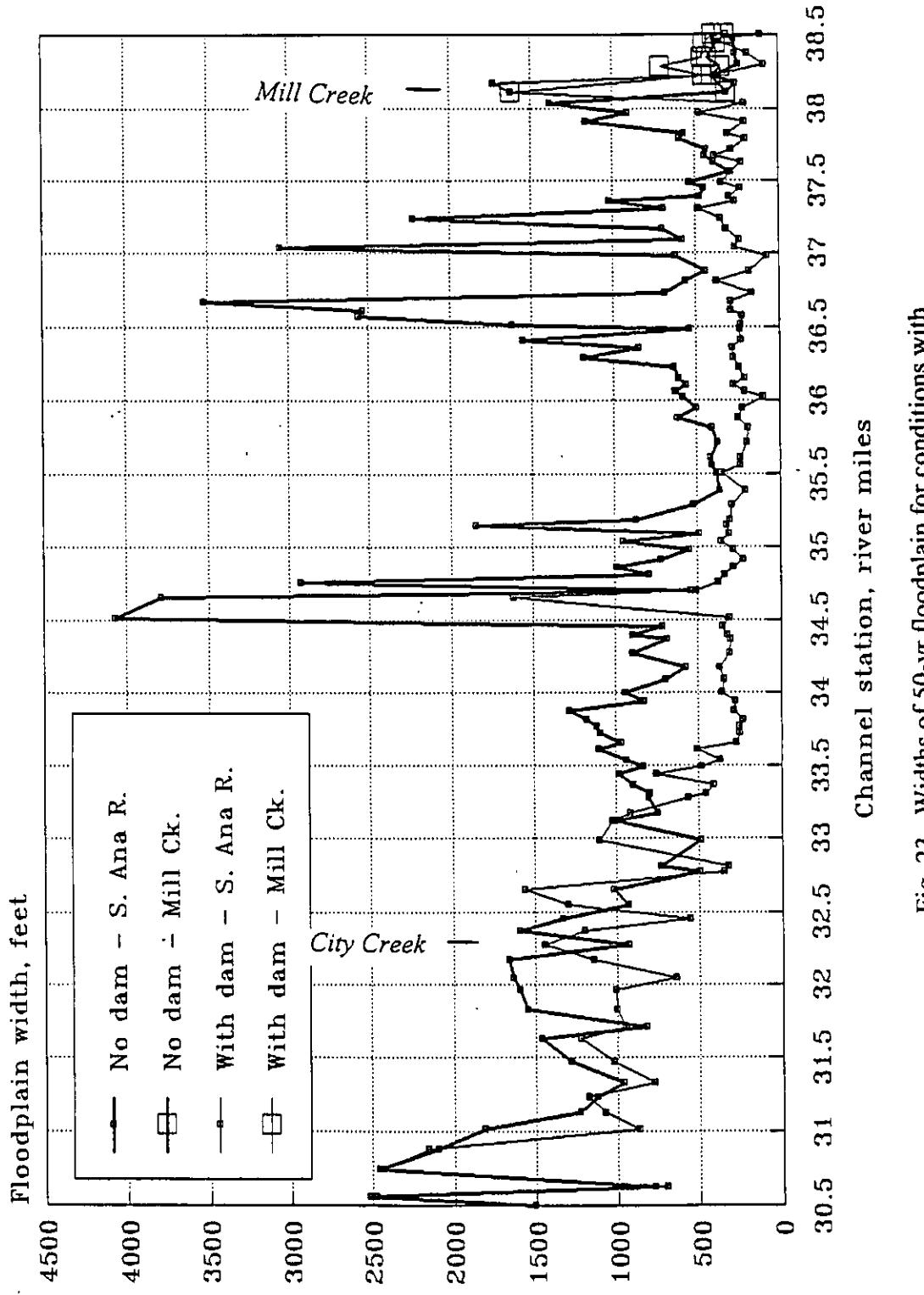


Fig. 23. Widths of 50-yr floodplain for conditions with and without the dam - long-term changes

Santa Ana River
Floodplain Area per Half-Mile Reach
for 100-yr Flood

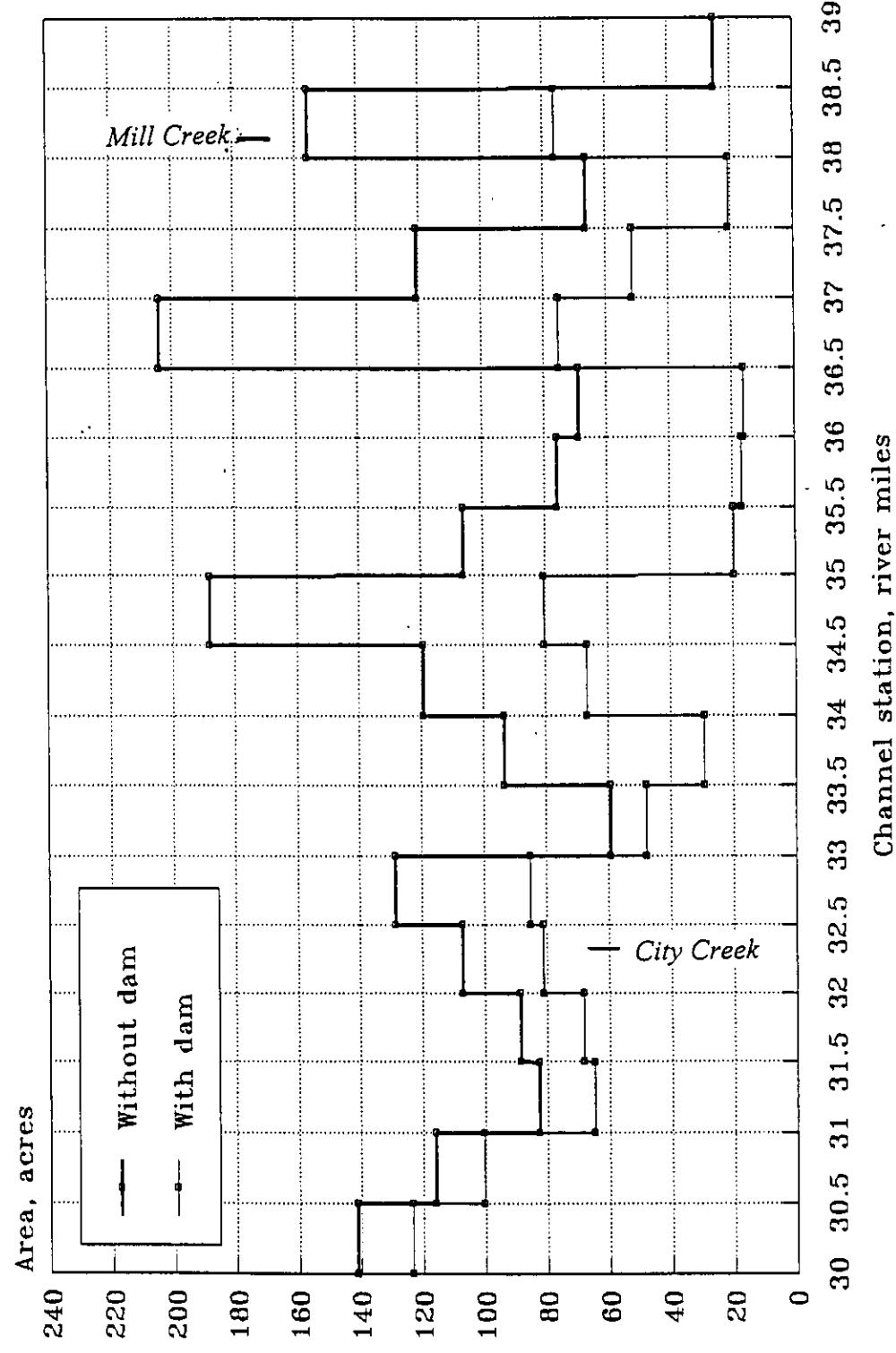


Fig. 24. Areas of 100-yr floodplain for conditions with
and without the dam - long-term changes

Santa Ana River
 Floodplain Area per Half-Mile Reach
 for 50-yr Flood

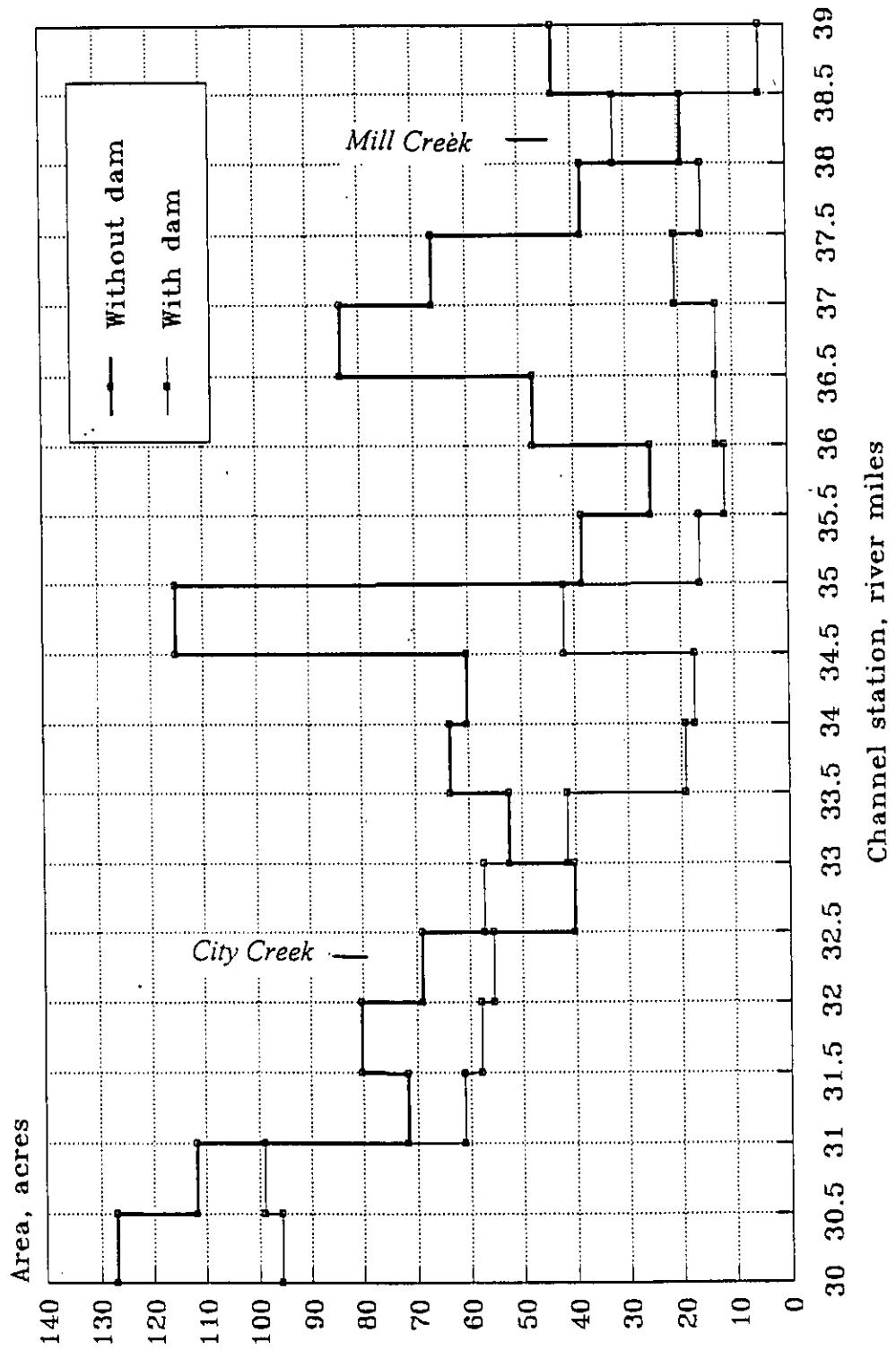


Fig. 25. Areas of 50-yr floodplain for conditions with and without the dam - long-term changes

APPENDIX A.

Table A-1. Computed 100-yr flood elevations and short-term changes before Seven Oaks Dam

Table A-2. Computed 50-yr flood elevations and short-term changes before Seven Oaks Dam

Table A-3. Computed 100-yr flood elevations and short-term changes after Seven Oaks Dam

Table A-4. Computed 50-yr flood elevations and short-term changes after Seven Oaks Dam

Table A-5. Computed 100-yr flood elevations and long-term changes before Seven Oaks Dam

Table A-6. Computed 50-yr flood elevations and long-term changes before Seven Oaks Dam

Table A-7. Computed 100-yr flood elevations and long-term changes after Seven Oaks Dam

Table A-8. Computed 50-yr flood elevations and long-term changes after Seven Oaks Dam

Fig. A-1. Water-surface profile at peak flow and channel-bed changes during the flood series
- before Seven Oaks Dam

Fig. A-2. Water-surface profile at peak flow and channel-bed changes during the flood series
- after Seven Oaks Dam

Fig. A-3. Sample cross-sectional changes during 100-yr flood series before and after Seven Oaks
Dam

Table A-1. Computed 100-yr flood elevations and short-term changes before Seven Oaks Dam

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	Next 100-yr flood (Case 2)	Difference
29.64	1055.1	1055.1	0.0
29.80	1059.9	1058.9	-1.0
29.99	1065.5	1065.7	0.2
30.12	1067.1	1068.1	1.0
30.26	1072.2	1072.4	0.2
30.38	1076.1	1076.3	0.2
30.45	1077.1	1078.3	1.3
30.56	1084.5	1082.3	-2.2
30.63	1085.2	1083.2	-2.0
30.75	1092.6	1088.8	-3.7
30.88	1093.9	1094.3	0.4
31.02	1098.6	1098.9	0.3
31.13	1105.7	1103.6	-2.1
31.23	1108.1	1108.0	0.0
31.33	1112.1	1112.0	-0.1
31.47	1120.6	1117.1	-3.5
31.63	1125.2	1125.7	0.5
31.71	1129.5	1128.4	-1.1
31.83	1136.1	1135.5	-0.6
31.96	1141.5	1140.6	-0.9
32.04	1145.4	1144.9	-0.5
32.17	1148.4	1149.1	0.8
32.27	1152.8	1153.5	0.7
32.37	1158.5	1158.0	-0.5
32.45	1163.8	1162.3	-1.5
32.55	1166.4	1166.0	-0.4
32.65	1173.4	1173.0	-0.4
32.77	1184.4	1177.2	-7.2
32.81	1189.8	1189.1	-0.7
32.99	1197.4	1198.9	1.5
33.12	1200.8	1204.4	3.5
33.17	1203.8	1206.9	3.1
33.28	1211.5	1212.1	0.6
33.31	1214.3	1214.1	-0.2
33.37	1218.8	1217.9	-1.0
33.44	1222.8	1222.2	-0.6
33.49	1226.1	1225.5	-0.6
33.54	1229.6	1229.2	-0.4
33.61	1236.1	1233.8	-2.3

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	Next 100-yr flood (Case 2)	Difference
33.66	1238.2	1237.3	-0.9
33.72	1241.6	1240.4	-1.1
33.77	1245.9	1244.0	-2.0
33.81	1248.7	1248.5	-0.2
33.87	1253.3	1253.5	0.2
33.94	1258.1	1258.3	0.3
34.00	1264.7	1264.6	-0.1
34.09	1271.5	1270.5	-1.0
34.17	1276.5	1276.4	-0.1
34.27	1283.4	1282.8	-0.5
34.36	1293.3	1288.2	-5.0
34.39	1297.3	1290.2	-7.1
34.45	1297.4	1295.4	-2.0
34.51	1297.7	1299.2	1.5
34.65	1308.0	1308.9	0.9
34.70	1314.2	1313.9	-0.2
34.76	1318.2	1318.9	0.7
34.81	1323.4	1322.8	-0.6
34.86	1327.7	1327.7	0.0
34.91	1332.1	1332.3	0.2
34.98	1337.3	1338.4	1.1
35.04	1343.5	1343.8	0.4
35.09	1348.2	1348.7	0.5
35.15	1355.2	1355.4	0.1
35.19	1359.1	1359.7	0.5
35.29	1368.3	1368.6	0.4
35.39	1378.5	1373.4	-5.1
35.51	1388.0	1387.2	-0.8
35.56	1393.1	1394.4	1.3
35.61	1398.2	1399.1	0.9
35.72	1408.7	1408.9	0.2
35.81	1416.6	1419.3	2.8
35.88	1424.1	1426.0	1.9
35.95	1432.4	1433.6	1.2
36.02	1440.2	1436.8	-3.3
36.06	1443.9	1438.9	-5.0
36.10	1449.2	1448.9	-0.3
36.15	1453.5	1448.9	-4.6
36.22	1459.8	1455.6	-4.2
36.29	1465.9	1462.0	-3.9
36.36	1469.8	1466.4	-3.4

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	Next 100-yr flood (Case 2)	Difference
36.41	1476.8	1474.2	-2.7
36.48	1482.1	1478.7	-3.4
36.51	1487.2	1484.4	-2.8
36.57	1492.8	1489.3	-3.5
36.61	1496.3	1494.8	-1.5
36.67	1502.7	1503.2	0.5
36.73	1508.6	1511.0	2.4
36.81	1521.9	1518.8	-3.1
36.88	1528.3	1526.4	-1.9
36.98	1537.8	1541.4	3.7
37.04	1545.7	1547.5	1.9
37.09	1550.8	1554.1	3.3
37.17	1561.0	1559.3	-1.7
37.24	1570.9	1570.5	-0.4
37.31	1578.0	1580.9	3.0
37.36	1583.6	1585.3	1.8
37.39	1587.8	1590.3	2.5
37.45	1596.4	1597.4	1.0
37.49	1601.8	1605.1	3.3
37.56	1609.2	1612.9	3.7
37.63	1617.9	1621.5	3.6
37.67	1622.2	1626.5	4.3
37.72	1629.4	1632.2	2.8
37.79	1638.2	1640.1	1.9
37.83	1645.4	1646.7	1.3
37.91	1656.5	1657.0	0.5
37.97	1665.8	1665.4	-0.4
38.04	1671.9	1671.6	-0.3
38.11	1679.5	1681.0	1.5
38.17	1685.7	1687.5	1.8
38.22	1696.5	1696.5	0.0
38.30	1708.2	1704.0	-4.1
38.37	1718.3	1715.9	-2.4
38.47	1733.2	1732.0	-1.1
38.54	1745.9	1744.2	-1.7
38.61	1760.5	1757.3	-3.2
38.66	1767.8	1764.9	-2.9
38.71	1777.1	1775.4	-1.7
38.79	1789.2	1789.0	-0.1
38.83	1796.3	1797.9	1.6
38.86	1802.9	1806.1	3.2

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	Next 100-yr flood (Case 2)	Difference
38.92	1809.8	1814.4	4.6
38.97	1819.4	1824.2	4.8
39.05	1830.9	1837.4	6.6
39.10	1841.7	1846.7	5.0
39.15	1853.0	1856.7	3.8
39.18	1860.1	1866.6	6.6
39.24	1865.0	1871.1	6.0
39.35	1876.0	1879.1	3.1
39.42	1886.6	1887.7	1.2
39.49	1892.7	1894.1	1.4
The following sections are in Mill Creek			
38.22	1700.1	1701.0	1.0
38.28	1710.5	1714.7	4.2
38.34	1722.1	1724.3	2.2
38.44	1735.7	1738.9	3.2
38.52	1752.8	1754.8	2.0
38.60	1764.0	1768.0	3.9
38.64	1774.5	1777.2	2.7
38.69	1782.6	1783.9	1.3
38.77	1799.5	1800.9	1.4
38.83	1811.6	1813.9	2.3
38.91	1825.4	1828.1	2.7
38.96	1833.5	1834.9	1.5
39.07	1855.2	1856.4	1.2
39.19	1878.6	1880.5	2.0
39.27	1895.6	1897.9	2.3
39.36	1911.6	1914.2	2.5
39.43	1928.4	1932.0	3.7
39.51	1949.9	1953.7	3.9
39.56	1964.8	1967.8	3.1
39.63	1978.9	1983.5	4.7
39.68	1991.2	1995.5	4.3
39.76	2003.7	2008.2	4.5
39.83	2022.1	2022.4	0.4
39.91	2033.4	2035.4	2.0
40.00	2049.2	2051.2	1.9
40.08	2067.7	2070.7	2.9
40.16	2083.0	2088.9	5.9
40.28	2107.6	2107.6	0.0

Table A-2. Computed 50-yr flood elevations and short-term changes before Seven Oaks Dam

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	Next 50-yr flood (Case 5)	Difference
29.64	1050.4	1050.4	0.0
29.80	1056.9	1055.8	-1.0
29.99	1063.4	1063.9	0.4
30.12	1065.1	1066.1	0.9
30.26	1071.4	1071.1	-0.3
30.38	1074.5	1074.7	0.2
30.45	1075.9	1076.3	0.4
30.56	1080.4	1080.2	-0.2
30.63	1083.0	1082.0	-1.0
30.75	1089.7	1087.7	-2.0
30.88	1092.0	1092.9	0.9
31.02	1097.5	1097.4	0.0
31.13	1102.4	1101.7	-0.7
31.23	1105.9	1105.8	-0.2
31.33	1110.6	1110.5	-0.1
31.47	1117.7	1117.1	-0.6
31.63	1122.5	1123.3	0.8
31.71	1128.6	1127.0	-1.6
31.83	1134.1	1133.9	-0.2
31.96	1138.7	1138.8	0.1
32.04	1144.3	1142.8	-1.5
32.17	1146.8	1147.4	0.6
32.27	1151.7	1152.1	0.4
32.37	1156.9	1156.6	-0.3
32.45	1162.0	1160.6	-1.4
32.55	1164.8	1163.9	-0.9
32.65	1170.6	1171.9	1.4
32.77	1183.3	1177.1	-6.2
32.81	1188.7	1187.9	-0.8
32.99	1196.0	1197.2	1.2
33.12	1199.1	1199.6	0.5
33.17	1202.0	1204.1	2.1
33.28	1208.2	1209.2	1.0
33.31	1212.6	1211.6	-1.0
33.37	1216.1	1215.5	-0.6
33.44	1220.8	1220.1	-0.6
33.49	1223.9	1223.6	-0.3
33.54	1227.6	1227.3	-0.2
33.61	1233.9	1232.4	-1.5

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	Next 50-yr flood (Case 5)	Difference
33.66	1236.2	1236.1	-0.1
33.72	1240.2	1239.7	-0.5
33.77	1243.6	1243.2	-0.4
33.81	1246.7	1247.4	0.6
33.87	1251.5	1252.2	0.7
33.94	1257.0	1257.3	0.2
34.00	1263.6	1263.7	0.1
34.09	1268.6	1269.5	0.9
34.17	1276.2	1275.5	-0.7
34.27	1282.4	1281.9	-0.4
34.36	1290.8	1286.8	-4.0
34.39	1294.1	1290.8	-3.3
34.45	1294.2	1292.8	-1.4
34.51	1295.3	1297.5	2.1
34.65	1306.8	1306.7	-0.1
34.70	1312.7	1309.6	-3.1
34.76	1316.6	1316.1	-0.5
34.81	1320.9	1320.2	-0.7
34.86	1324.8	1324.1	-0.7
34.91	1331.0	1329.9	-1.1
34.98	1336.1	1336.7	0.6
35.04	1342.2	1342.2	0.0
35.09	1347.0	1348.0	1.1
35.15	1353.4	1354.2	0.8
35.19	1357.7	1359.2	1.5
35.29	1366.6	1367.3	0.7
35.39	1375.8	1377.3	1.5
35.51	1387.3	1382.1	-5.2
35.56	1391.9	1387.0	-4.9
35.61	1396.8	1391.0	-5.8
35.72	1406.1	1405.5	-0.7
35.81	1414.4	1416.5	2.1
35.88	1422.5	1422.0	-0.4
35.95	1429.9	1426.8	-3.1
36.02	1438.4	1433.1	-5.3
36.06	1443.2	1445.4	2.2
36.10	1446.9	1446.9	0.0
36.15	1452.1	1449.6	-2.6
36.22	1459.0	1454.5	-4.5
36.29	1463.1	1460.4	-2.7
36.36	1468.0	1466.3	-1.7

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	Next 50-yr flood (Case 5)	Difference
36.41	1475.0	1472.3	-2.7
36.48	1481.0	1481.2	0.2
36.51	1485.8	1484.2	-1.6
36.57	1491.5	1490.8	-0.8
36.61	1494.4	1496.5	2.1
36.67	1499.7	1502.2	2.4
36.73	1506.8	1506.9	0.1
36.81	1521.0	1518.5	-2.5
36.88	1527.6	1526.1	-1.6
36.98	1537.5	1540.4	2.9
37.04	1543.5	1545.8	2.3
37.09	1548.6	1551.2	2.7
37.17	1558.4	1559.0	0.6
37.24	1568.3	1568.0	-0.3
37.31	1576.7	1578.5	1.7
37.36	1581.8	1582.4	0.6
37.39	1586.1	1587.2	1.2
37.45	1594.5	1594.1	-0.4
37.49	1599.2	1602.2	3.1
37.56	1607.4	1609.1	1.7
37.63	1615.9	1618.1	2.2
37.67	1620.6	1623.2	2.5
37.72	1627.5	1628.4	0.9
37.79	1637.1	1636.5	-0.6
37.83	1642.5	1643.8	1.3
37.91	1653.8	1653.4	-0.4
37.97	1661.7	1662.0	0.3
38.04	1668.8	1670.9	2.1
38.11	1677.9	1677.8	-0.2
38.17	1683.7	1681.4	-2.3
38.22	1694.4	1691.4	-3.0
38.30	1706.8	1707.9	1.1
38.37	1716.6	1718.0	1.4
38.47	1731.2	1733.3	2.1
38.54	1743.2	1743.9	0.7
38.61	1758.6	1756.3	-2.3
38.66	1766.5	1765.1	-1.4
38.71	1776.4	1773.6	-2.8
38.79	1787.3	1786.9	-0.4
38.83	1793.9	1796.0	2.0
38.86	1802.3	1801.9	-0.4

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	Next 50-yr flood (Case 5)	Difference
38.92	1808.2	1811.9	3.7
38.97	1817.7	1821.4	3.7
39.05	1829.2	1832.7	3.5
39.10	1837.8	1842.3	4.5
39.15	1847.8	1851.7	3.9
39.18	1858.5	1863.1	4.6
39.24	1861.3	1868.2	6.9
39.35	1873.3	1877.4	4.1
39.42	1883.4	1883.9	0.5
39.49	1889.8	1893.0	3.2
The following sections are in Mill Creek			
38.22	1698.9	1698.9	0.0
38.28	1709.4	1711.4	2.1
38.34	1720.8	1721.8	1.0
38.44	1734.4	1736.5	2.1
38.52	1751.4	1752.2	0.8
38.60	1762.7	1766.0	3.2
38.64	1772.9	1774.9	2.0
38.69	1781.2	1782.2	1.0
38.77	1798.0	1798.9	0.8
38.83	1810.0	1810.9	0.9
38.91	1824.2	1825.5	1.3
38.96	1832.1	1833.3	1.2
39.07	1854.0	1854.8	0.8
39.19	1877.4	1878.0	0.6
39.27	1894.6	1895.8	1.3
39.36	1910.5	1912.3	1.8
39.43	1927.5	1929.7	2.2
39.51	1949.0	1951.2	2.2
39.56	1963.7	1965.9	2.2
39.63	1977.5	1980.7	3.2
39.68	1989.4	1992.4	3.0
39.76	2001.5	2005.2	3.6
39.83	2019.5	2019.9	0.4
39.91	2031.3	2032.6	1.3
40.00	2048.1	2049.1	1.0
40.08	2066.4	2067.4	1.1
40.16	2082.1	2087.1	5.0
40.28	2106.5	2106.5	0.0

Table A-3. Computed 100-yr flood elevations and short-term changes after Seven Oaks Dam

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	Next 100-yr flood (Case 3)	Difference
29.64	1055.1	1048.0	-7.1
29.80	1059.9	1053.7	-6.2
29.99	1065.5	1062.5	-3.0
30.12	1067.1	1064.6	-2.4
30.26	1072.2	1068.7	-3.4
30.38	1076.1	1072.9	-3.1
30.45	1077.1	1075.1	-1.9
30.56	1084.5	1078.8	-5.6
30.63	1085.2	1080.9	-4.3
30.75	1092.6	1087.0	-5.6
30.88	1093.9	1092.0	-1.8
31.02	1098.6	1096.2	-2.4
31.13	1105.7	1100.7	-5.0
31.23	1108.1	1105.1	-2.9
31.33	1112.1	1109.5	-2.6
31.47	1120.6	1115.9	-4.7
31.63	1125.2	1122.0	-3.3
31.71	1129.5	1126.2	-3.3
31.83	1136.1	1132.9	-3.2
31.96	1141.5	1138.3	-3.2
32.04	1145.4	1142.3	-3.1
32.17	1148.4	1146.3	-2.1
32.27	1152.8	1151.1	-1.8
32.37	1158.5	1155.8	-2.7
32.45	1163.8	1158.4	-5.4
32.55	1166.4	1163.6	-2.8
32.65	1173.4	1170.9	-2.5
32.77	1184.4	1178.1	-6.3
32.81	1189.8	1187.4	-2.4
32.99	1197.4	1195.9	-1.6
33.12	1200.8	1199.7	-1.1
33.17	1203.8	1202.1	-1.7
33.28	1211.5	1207.6	-4.0
33.31	1214.3	1208.7	-5.6
33.37	1218.8	1213.5	-5.3
33.44	1222.8	1219.2	-3.6
33.49	1226.1	1222.2	-3.9
33.54	1229.6	1224.9	-4.7
33.61	1236.1	1230.9	-5.2

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	Next 100-yr flood (Case 3)	Difference
33.66	1238.2	1234.2	-4.0
33.72	1241.6	1237.9	-3.7
33.77	1245.9	1241.6	-4.3
33.81	1248.7	1246.0	-2.7
33.87	1253.3	1251.0	-2.3
33.94	1258.1	1256.1	-2.0
34.00	1264.7	1262.5	-2.2
34.09	1271.5	1268.4	-3.1
34.17	1276.5	1272.8	-3.7
34.27	1283.4	1277.0	-6.4
34.36	1293.3	1283.5	-9.8
34.39	1297.3	1287.7	-9.6
34.45	1297.4	1291.7	-5.7
34.51	1297.7	1295.7	-2.0
34.65	1308.0	1306.6	-1.4
34.70	1314.2	1310.1	-4.1
34.76	1318.2	1316.1	-2.1
34.81	1323.4	1318.1	-5.3
34.86	1327.7	1322.1	-5.6
34.91	1332.1	1328.4	-3.6
34.98	1337.3	1332.7	-4.5
35.04	1343.5	1341.2	-2.2
35.09	1348.2	1344.1	-4.1
35.15	1355.2	1351.8	-3.4
35.19	1359.1	1356.8	-2.3
35.29	1368.3	1365.5	-2.8
35.39	1378.5	1375.6	-2.9
35.51	1388.0	1385.9	-2.2
35.56	1393.1	1391.7	-1.5
35.61	1398.2	1396.7	-1.5
35.72	1408.7	1405.8	-2.9
35.81	1416.6	1414.3	-2.2
35.88	1424.1	1421.9	-2.2
35.95	1432.4	1427.2	-5.2
36.02	1440.2	1432.0	-8.2
36.06	1443.9	1437.6	-6.3
36.10	1449.2	1441.3	-7.9
36.15	1453.5	1447.4	-6.1
36.22	1459.8	1453.2	-6.6
36.29	1465.9	1459.0	-6.9
36.36	1469.8	1464.6	-5.2

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	Next 100-yr flood (Case 3)	Difference
36.41	1476.8	1472.6	-4.2
36.48	1482.1	1480.4	-1.8
36.51	1487.2	1484.2	-3.0
36.57	1492.8	1488.8	-4.0
36.61	1496.3	1494.1	-2.2
36.67	1502.7	1500.5	-2.3
36.73	1508.6	1505.8	-2.8
36.81	1521.9	1517.4	-4.5
36.88	1528.3	1526.0	-2.3
36.98	1537.8	1538.8	1.0
37.04	1545.7	1542.5	-3.2
37.09	1550.8	1548.1	-2.7
37.17	1561.0	1558.0	-2.9
37.24	1570.9	1566.1	-4.8
37.31	1578.0	1576.6	-1.4
37.36	1583.6	1580.1	-3.5
37.39	1587.8	1585.4	-2.4
37.45	1596.4	1592.0	-4.5
37.49	1601.8	1598.7	-3.1
37.56	1609.2	1607.7	-1.4
37.63	1617.9	1615.0	-2.9
37.67	1622.2	1620.3	-1.9
37.72	1629.4	1626.0	-3.4
37.79	1638.2	1633.8	-4.4
37.83	1645.4	1641.2	-4.2
37.91	1656.5	1651.6	-5.0
37.97	1665.8	1659.1	-6.7
38.04	1671.9	1665.3	-6.6
38.11	1679.5	1681.6	2.1
38.17	1685.7	1685.6	-0.2
38.22	1696.5	1686.8	-9.7
38.30	1708.2	1702.3	-5.9
38.37	1718.3	1713.9	-4.4
38.47	1733.2	1726.3	-6.8
38.54	1745.9	1739.9	-6.0
38.61	1760.5	1752.3	-8.2
38.66	1767.8	1761.5	-6.3
38.71	1777.1	1771.1	-6.1
38.79	1789.2	1784.5	-4.6
38.83	1796.3	1789.3	-7.0
38.86	1802.9	1795.1	-7.8

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	Next 100-yr flood (Case 3)	Difference
38.92	1809.8	1805.3	-4.5
38.97	1819.4	1812.3	-7.1
39.05	1830.9	1824.5	-6.3
39.10	1841.7	1830.5	-11.1
39.15	1853.0	1841.9	-11.0
39.18	1860.1	1850.9	-9.2
39.24	1865.0	1855.7	-9.4
39.35	1876.0	1864.8	-11.2
39.42	1886.6	1871.7	-14.9
39.49	1892.7	1884.7	-8.0
The following sections are in Mill Creek			
38.22	1700.1	1703.2	3.2
38.28	1710.5	1715.2	4.8
38.34	1722.1	1724.5	2.5
38.44	1735.7	1739.4	3.7
38.52	1752.8	1754.7	1.8
38.60	1764.0	1768.2	4.2
38.64	1774.5	1777.4	2.9
38.69	1782.6	1784.0	1.5
38.77	1799.5	1800.9	1.3
38.83	1811.6	1813.7	2.1
38.91	1825.4	1827.5	2.1
38.96	1833.5	1835.3	1.8
39.07	1855.2	1856.7	1.5
39.19	1878.6	1880.6	2.0
39.27	1895.6	1897.9	2.3
39.36	1911.6	1914.2	2.6
39.43	1928.4	1931.8	3.4
39.51	1949.9	1953.4	3.5
39.56	1964.8	1968.8	4.0
39.63	1978.9	1985.8	6.9
39.68	1991.2	1999.3	8.2
39.76	2003.7	2011.7	8.0
39.83	2022.1	2023.9	1.8
39.91	2033.4	2036.6	3.2
40.00	2049.2	2052.4	3.1
40.08	2067.7	2071.9	4.2
40.16	2083.0	2089.9	6.9
40.28	2107.6	2107.8	0.3

Table A-4. Computed 50-yr flood elevations and short-term changes after Seven Oaks Dam

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	Next 50-yr flood (Case 6)	Difference
29.64	1050.4	1047.3	-3.1
29.80	1056.9	1052.5	-4.3
29.99	1063.4	1060.8	-2.6
30.12	1065.1	1062.7	-2.4
30.26	1071.4	1066.9	-4.5
30.38	1074.5	1071.4	-3.0
30.45	1075.9	1073.8	-2.0
30.56	1080.4	1077.5	-2.8
30.63	1083.0	1080.2	-2.8
30.75	1089.7	1086.4	-3.4
30.88	1092.0	1091.3	-0.8
31.02	1097.5	1095.3	-2.1
31.13	1102.4	1099.6	-2.9
31.23	1105.9	1104.1	-1.9
31.33	1110.6	1108.9	-1.6
31.47	1117.7	1112.9	-4.7
31.63	1122.5	1121.6	-0.9
31.71	1128.6	1125.0	-3.6
31.83	1134.1	1132.4	-1.7
31.96	1138.7	1137.4	-1.3
32.04	1144.3	1141.5	-2.8
32.17	1146.8	1145.5	-1.3
32.27	1151.7	1148.4	-3.3
32.37	1156.9	1155.3	-1.6
32.45	1162.0	1157.6	-4.4
32.55	1164.8	1161.7	-3.1
32.65	1170.6	1170.2	-0.3
32.77	1183.3	1174.3	-9.0
32.81	1188.7	1186.8	-1.9
32.99	1196.0	1193.9	-2.1
33.12	1199.1	1197.3	-1.8
33.17	1202.0	1200.0	-2.0
33.28	1208.2	1206.7	-1.5
33.31	1212.6	1209.0	-3.6
33.37	1216.1	1213.3	-2.7
33.44	1220.8	1217.2	-3.5
33.49	1223.9	1221.2	-2.7
33.54	1227.6	1224.1	-3.4
33.61	1233.9	1230.1	-3.8

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	Next 50-yr flood (Case 6)	Difference
33.66	1236.2	1233.5	-2.7
33.72	1240.2	1236.2	-4.0
33.77	1243.6	1240.3	-3.3
33.81	1246.7	1244.2	-2.5
33.87	1251.5	1249.3	-2.2
33.94	1257.0	1253.2	-3.9
34.00	1263.6	1259.1	-4.5
34.09	1268.6	1264.0	-4.6
34.17	1276.2	1270.3	-5.8
34.27	1282.4	1276.6	-5.8
34.36	1290.8	1283.4	-7.4
34.39	1294.1	1287.6	-6.6
34.45	1294.2	1289.7	-4.5
34.51	1295.3	1294.4	-0.9
34.65	1306.8	1304.1	-2.7
34.70	1312.7	1307.0	-5.7
34.76	1316.6	1312.6	-4.0
34.81	1320.9	1317.1	-3.8
34.86	1324.8	1321.9	-2.9
34.91	1331.0	1327.5	-3.5
34.98	1336.1	1333.2	-3.0
35.04	1342.2	1338.7	-3.6
35.09	1347.0	1343.5	-3.4
35.15	1353.4	1348.4	-4.9
35.19	1357.7	1356.7	-1.0
35.29	1366.6	1362.3	-4.2
35.39	1375.8	1375.7	-0.1
35.51	1387.3	1385.4	-1.9
35.56	1391.9	1389.1	-2.8
35.61	1396.8	1396.1	-0.7
35.72	1406.1	1402.6	-3.5
35.81	1414.4	1413.5	-0.9
35.88	1422.5	1418.8	-3.6
35.95	1429.9	1427.8	-2.1
36.02	1438.4	1431.6	-6.7
36.06	1443.2	1436.4	-6.7
36.10	1446.9	1441.6	-5.3
36.15	1452.1	1446.4	-5.7
36.22	1459.0	1452.4	-6.6
36.29	1463.1	1457.7	-5.4
36.36	1468.0	1464.2	-3.7

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	Next 50-yr flood (Case 6)	Difference
36.41	1475.0	1471.7	-3.2
36.48	1481.0	1478.1	-2.9
36.51	1485.8	1483.3	-2.5
36.57	1491.5	1488.1	-3.5
36.61	1494.4	1493.4	-1.0
36.67	1499.7	1498.4	-1.3
36.73	1506.8	1503.6	-3.2
36.81	1521.0	1516.8	-4.2
36.88	1527.6	1525.9	-1.7
36.98	1537.5	1536.2	-1.3
37.04	1543.5	1542.1	-1.4
37.09	1548.6	1548.7	0.2
37.17	1558.4	1555.6	-2.8
37.24	1568.3	1564.3	-4.0
37.31	1576.7	1571.6	-5.1
37.36	1581.8	1577.1	-4.7
37.39	1586.1	1582.7	-3.4
37.45	1594.5	1590.7	-3.8
37.49	1599.2	1597.2	-2.0
37.56	1607.4	1602.9	-4.5
37.63	1615.9	1610.9	-4.9
37.67	1620.6	1617.2	-3.5
37.72	1627.5	1622.0	-5.6
37.79	1637.1	1630.0	-7.1
37.83	1642.5	1639.8	-2.7
37.91	1653.8	1651.7	-2.1
37.97	1661.7	1657.4	-4.3
38.04	1668.8	1665.6	-3.2
38.11	1677.9	1676.8	-1.2
38.17	1683.7	1682.7	-1.0
38.22	1694.4	1686.4	-8.0
38.30	1706.8	1702.1	-4.7
38.37	1716.6	1713.3	-3.3
38.47	1731.2	1726.5	-4.7
38.54	1743.2	1739.3	-3.9
38.61	1758.6	1751.2	-7.4
38.66	1766.5	1762.6	-3.9
38.71	1776.4	1771.3	-5.1
38.79	1787.3	1783.9	-3.4
38.83	1793.9	1788.1	-5.9
38.86	1802.3	1795.1	-7.1

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	Next 50-yr flood (Case 6)	Difference
38.92	1808.2	1804.2	-4.0
38.97	1817.7	1812.5	-5.2
39.05	1829.2	1824.3	-4.9
39.10	1837.8	1829.7	-8.1
39.15	1847.8	1841.7	-6.1
39.18	1858.5	1850.2	-8.3
39.24	1861.3	1855.0	-6.3
39.35	1873.3	1865.2	-8.2
39.42	1883.4	1874.0	-9.4
39.49	1889.8	1883.5	-6.3
The following sections are in Mill Creek			
38.22	1698.9	1700.3	1.4
38.28	1709.4	1711.9	2.6
38.34	1720.8	1721.7	0.9
38.44	1734.4	1736.4	1.9
38.52	1751.4	1751.9	0.5
38.60	1762.7	1765.8	3.1
38.64	1772.9	1774.7	1.8
38.69	1781.2	1782.0	0.8
38.77	1798.0	1798.8	0.8
38.83	1810.0	1811.0	1.0
38.91	1824.2	1825.2	1.0
38.96	1832.1	1833.4	1.3
39.07	1854.0	1854.8	0.7
39.19	1877.4	1878.1	0.6
39.27	1894.6	1895.6	1.1
39.36	1910.5	1912.6	2.1
39.43	1927.5	1929.3	1.8
39.51	1949.0	1950.9	1.9
39.56	1963.7	1965.5	1.8
39.63	1977.5	1981.0	3.5
39.68	1989.4	1993.0	3.5
39.76	2001.5	2006.1	4.6
39.83	2019.5	2020.1	0.6
39.91	2031.3	2033.0	1.7
40.00	2048.1	2049.3	1.1
40.08	2066.4	2067.4	1.0
40.16	2082.1	2086.9	4.8
40.28	2106.5	2106.6	0.1

Table A-5. Computed 100-yr flood elevations and long-term changes before Seven Oaks Dam

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	100 years later (Case 7)	Difference
29.64	1055.1	1055.1	0.0
29.80	1059.9	1059.1	-0.8
29.99	1065.5	1067.0	1.5
30.12	1067.1	1069.3	2.2
30.26	1072.2	1074.0	1.9
30.38	1076.1	1078.2	2.1
30.45	1077.1	1081.3	4.2
30.56	1084.5	1085.1	0.6
30.63	1085.2	1086.6	1.4
30.75	1092.6	1093.2	0.6
30.88	1093.9	1096.1	2.3
31.02	1098.6	1102.4	3.8
31.13	1105.7	1105.7	0.1
31.23	1108.1	1109.3	1.2
31.33	1112.1	1114.1	2.0
31.47	1120.6	1120.9	0.3
31.63	1125.2	1126.2	0.9
31.71	1129.5	1130.2	0.7
31.83	1136.1	1137.2	1.1
31.96	1141.5	1141.0	-0.5
32.04	1145.4	1145.5	0.1
32.17	1148.4	1149.3	1.0
32.27	1152.8	1154.9	2.1
32.37	1158.5	1159.9	1.4
32.45	1163.8	1163.4	-0.3
32.55	1166.4	1168.5	2.1
32.65	1173.4	1175.5	2.1
32.77	1184.4	1182.7	-1.6
32.81	1189.8	1188.5	-1.3
32.99	1197.4	1197.6	0.2
33.12	1200.8	1202.6	1.8
33.17	1203.8	1205.8	1.9
33.28	1211.5	1211.2	-0.3
33.31	1214.3	1212.4	-1.9
33.37	1218.8	1217.7	-1.1
33.44	1222.8	1222.1	-0.7
33.49	1226.1	1225.3	-0.8
33.54	1229.6	1230.0	0.5
33.61	1236.1	1232.9	-3.2

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	100 years later (Case 7)	Difference
33.66	1238.2	1239.0	0.8
33.72	1241.6	1241.8	0.2
33.77	1245.9	1246.0	0.1
33.81	1248.7	1249.9	1.2
33.87	1253.3	1254.8	1.6
33.94	1258.1	1259.8	1.8
34.00	1264.7	1265.7	1.0
34.09	1271.5	1271.1	-0.3
34.17	1276.5	1276.8	0.3
34.27	1283.4	1282.2	-1.2
34.36	1293.3	1287.4	-5.9
34.39	1297.3	1291.7	-5.6
34.45	1297.4	1295.7	-1.6
34.51	1297.7	1300.8	3.1
34.65	1308.0	1311.1	3.1
34.70	1314.2	1317.1	3.0
34.76	1318.2	1321.6	3.4
34.81	1323.4	1326.3	2.9
34.86	1327.7	1330.9	3.1
34.91	1332.1	1334.7	2.6
34.98	1337.3	1341.8	4.5
35.04	1343.5	1346.8	3.3
35.09	1348.2	1351.8	3.6
35.15	1355.2	1357.1	1.8
35.19	1359.1	1361.4	2.3
35.29	1368.3	1370.6	2.4
35.39	1378.5	1380.5	2.0
35.51	1388.0	1389.7	1.7
35.56	1393.1	1395.2	2.0
35.61	1398.2	1400.5	2.3
35.72	1408.7	1409.7	1.0
35.81	1416.6	1418.8	2.2
35.88	1424.1	1423.8	-0.3
35.95	1432.4	1429.7	-2.7
36.02	1440.2	1436.0	-4.2
36.06	1443.9	1439.6	-4.4
36.10	1449.2	1443.5	-5.7
36.15	1453.5	1448.9	-4.6
36.22	1459.8	1457.5	-2.3

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	100 years later (Case 7)	Difference
36.29	1465.9	1462.4	-3.5
36.36	1469.8	1467.8	-2.0
36.41	1476.8	1475.3	-1.5
36.48	1482.1	1481.8	-0.3
36.51	1487.2	1486.7	-0.5
36.57	1492.8	1492.2	-0.6
36.61	1496.3	1497.4	1.1
36.67	1502.7	1504.1	1.4
36.73	1508.6	1510.9	2.4
36.81	1521.9	1521.7	-0.2
36.88	1528.3	1528.7	0.4
36.98	1537.8	1540.7	2.9
37.04	1545.7	1548.5	2.8
37.09	1550.8	1553.8	3.0
37.17	1561.0	1562.4	1.5
37.24	1570.9	1570.2	-0.7
37.31	1578.0	1578.8	0.8
37.36	1583.6	1582.6	-1.0
37.39	1587.8	1589.3	1.5
37.45	1596.4	1598.5	2.1
37.49	1601.8	1605.3	3.6
37.56	1609.2	1613.3	4.1
37.63	1617.9	1621.4	3.5
37.67	1622.2	1625.7	3.5
37.72	1629.4	1631.5	2.1
37.79	1638.2	1637.8	-0.4
37.83	1645.4	1645.4	0.0
37.91	1656.5	1654.8	-1.7
37.97	1665.8	1664.4	-1.4
38.04	1671.9	1673.1	1.2
38.11	1679.5	1680.9	1.5
38.17	1685.7	1689.0	3.3
38.22	1696.5	1694.9	-1.6
38.30	1708.2	1708.3	0.2
38.37	1718.3	1716.0	-2.3
38.47	1733.2	1728.6	-4.6
38.54	1745.9	1740.1	-5.8
38.61	1760.5	1753.3	-7.2
38.66	1767.8	1765.1	-2.7

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 1)	100 years later (Case 7)	Difference
38.71	1777.1	1777.8	0.7
38.79	1789.2	1791.4	2.3
38.83	1796.3	1803.9	7.6
38.86	1802.9	1810.3	7.4
38.92	1809.8	1819.2	9.3
38.97	1819.4	1827.9	8.5
39.05	1830.9	1838.4	7.5
39.10	1841.7	1843.6	1.9
39.15	1853.0	1851.9	-1.1
39.18	1860.1	1865.8	5.7
39.24	1865.0	1870.5	5.5
39.35	1876.0	1881.6	5.6
39.42	1886.6	1887.5	0.9
39.49	1892.7	1894.7	2.0
The following sections are along Mill Creek			
38.22	1700.1	1705.9	5.8
38.28	1710.5	1716.2	5.7
38.34	1722.1	1726.3	4.2
38.44	1735.7	1742.8	7.0
38.52	1752.8	1758.7	5.9
38.60	1764.0	1773.9	9.9
38.64	1774.5	1785.2	10.7
38.69	1782.6	1793.7	11.1
38.77	1799.5	1809.1	9.6
38.83	1811.6	1820.1	8.5
38.91	1825.4	1835.1	9.6
38.96	1833.5	1843.6	10.1
39.07	1855.2	1863.9	8.7
39.19	1878.6	1885.5	6.9
39.27	1895.6	1901.5	5.9
39.36	1911.6	1920.3	8.7
39.43	1928.4	1935.9	7.6
39.51	1949.9	1959.7	9.8
39.56	1964.8	1972.9	8.1
39.63	1978.9	1993.7	14.8
39.68	1991.2	2007.6	16.4
39.76	2003.7	2022.2	18.4
39.83	2022.1	2036.2	14.1
39.91	2033.4	2048.5	15.0

Table A-6. Computed 50-yr flood elevations and long-term changes before Seven Oaks Dam

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	100 years later (Case 9)	Difference
29.64	1050.4	1050.4	0.0
29.80	1056.9	1055.1	-1.8
29.99	1063.4	1065.1	1.6
30.12	1065.1	1068.1	2.9
30.26	1071.4	1072.9	1.5
30.38	1074.5	1076.8	2.4
30.45	1075.9	1079.5	3.6
30.56	1080.4	1083.4	3.0
30.63	1083.0	1085.5	2.6
30.75	1089.7	1090.5	0.8
30.88	1092.0	1095.5	3.4
31.02	1097.5	1100.6	3.1
31.13	1102.4	1104.3	1.9
31.23	1105.9	1107.4	1.5
31.33	1110.6	1111.9	1.3
31.47	1117.7	1118.3	0.7
31.63	1122.5	1124.7	2.2
31.71	1128.6	1127.8	-0.7
31.83	1134.1	1134.8	0.7
31.96	1138.7	1140.1	1.4
32.04	1144.3	1143.8	-0.5
32.17	1146.8	1147.8	0.9
32.27	1151.7	1152.6	0.9
32.37	1156.9	1158.0	1.1
32.45	1162.0	1161.9	-0.1
32.55	1164.8	1165.8	1.1
32.65	1170.6	1172.5	1.9
32.77	1183.3	1177.7	-5.6
32.81	1188.7	1185.5	-3.2
32.99	1196.0	1193.4	-2.6
33.12	1199.1	1199.9	0.8
33.17	1202.0	1203.8	1.8
33.28	1208.2	1208.5	0.3
33.31	1212.6	1210.4	-2.2
33.37	1216.1	1215.0	-1.0
33.44	1220.8	1219.9	-0.8
33.49	1223.9	1223.0	-0.9
33.54	1227.6	1227.5	0.0
33.61	1233.9	1232.9	-1.0

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	100 years later (Case 9)	Difference
33.66	1236.2	1236.1	-0.1
33.72	1240.2	1240.1	-0.1
33.77	1243.6	1243.8	0.2
33.81	1246.7	1248.3	1.6
33.87	1251.5	1253.0	1.5
33.94	1257.0	1257.0	-0.1
34.00	1263.6	1262.9	-0.7
34.09	1268.6	1267.5	-1.1
34.17	1276.2	1272.7	-3.5
34.27	1282.4	1279.4	-3.0
34.36	1290.8	1283.5	-7.3
34.39	1294.1	1288.5	-5.7
34.45	1294.2	1291.8	-2.3
34.51	1295.3	1300.2	4.8
34.65	1306.8	1310.6	3.8
34.70	1312.7	1314.4	1.8
34.76	1316.6	1321.1	4.5
34.81	1320.9	1323.4	2.5
34.86	1324.8	1327.7	2.9
34.91	1331.0	1332.4	1.4
34.98	1336.1	1338.3	2.1
35.04	1342.2	1345.0	2.8
35.09	1347.0	1348.0	1.1
35.15	1353.4	1356.2	2.8
35.19	1357.7	1359.3	1.6
35.29	1366.6	1366.5	-0.1
35.39	1375.8	1375.9	0.1
35.51	1387.3	1384.4	-2.9
35.56	1391.9	1390.9	-1.0
35.61	1396.8	1394.8	-2.0
35.72	1406.1	1404.4	-1.7
35.81	1414.4	1413.1	-1.3
35.88	1422.5	1421.0	-1.4
35.95	1429.9	1426.4	-3.4
36.02	1438.4	1433.2	-5.1
36.06	1443.2	1436.8	-6.4
36.10	1446.9	1441.7	-5.2
36.15	1452.1	1446.2	-5.9
36.22	1459.0	1453.9	-5.1

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	100 years later (Case 9)	Difference
36.29	1463.1	1461.0	-2.0
36.36	1468.0	1465.8	-2.2
36.41	1475.0	1473.4	-1.6
36.48	1481.0	1479.2	-1.8
36.51	1485.8	1485.0	-0.8
36.57	1491.5	1491.4	-0.1
36.61	1494.4	1496.4	2.0
36.67	1499.7	1503.3	3.6
36.73	1506.8	1507.6	0.8
36.81	1521.0	1517.9	-3.1
36.88	1527.6	1525.3	-2.3
36.98	1537.5	1537.8	0.3
37.04	1543.5	1547.6	4.1
37.09	1548.6	1551.6	3.0
37.17	1558.4	1557.5	-1.0
37.24	1568.3	1569.6	1.3
37.31	1576.7	1576.4	-0.3
37.36	1581.8	1580.5	-1.3
37.39	1586.1	1586.4	0.3
37.45	1594.5	1594.9	0.4
37.49	1599.2	1601.6	2.4
37.56	1607.4	1607.3	-0.1
37.63	1615.9	1616.0	0.1
37.67	1620.6	1622.2	1.6
37.72	1627.5	1626.3	-1.2
37.79	1637.1	1634.8	-2.3
37.83	1642.5	1641.3	-1.2
37.91	1653.8	1653.3	-0.5
37.97	1661.7	1662.7	1.0
38.04	1668.8	1671.2	2.3
38.11	1677.9	1676.6	-1.4
38.17	1683.7	1683.1	-0.6
38.22	1694.4	1692.9	-1.5
38.30	1706.8	1702.6	-4.3
38.37	1716.6	1712.6	-4.1
38.47	1731.2	1724.8	-6.4
38.54	1743.2	1736.5	-6.7
38.61	1758.6	1750.1	-8.6
38.66	1766.5	1762.7	-3.8

Sec. No. River miles	Computed water-surface elevations, feet		
	Present (Case 4)	100 years later (Case 9)	Difference
38.71	1776.4	1773.5	-2.9
38.79	1787.3	1787.6	0.4
38.83	1793.9	1802.1	8.1
38.86	1802.3	1809.8	7.6
38.92	1808.2	1817.4	9.2
38.97	1817.7	1827.2	9.6
39.05	1829.2	1834.0	4.8
39.10	1837.8	1840.1	2.3
39.15	1847.8	1849.3	1.5
39.18	1858.5	1861.7	3.2
39.24	1861.3	1867.9	6.6
39.35	1873.3	1877.6	4.2
39.42	1883.4	1883.7	0.3
39.49	1889.8	1892.9	3.0
The following sections are along Mill Creek			
38.22	1698.9	1704.7	5.8
38.28	1709.4	1714.7	5.3
38.34	1720.8	1725.2	4.3
38.44	1734.4	1741.7	7.2
38.52	1751.4	1757.4	6.0
38.60	1762.7	1772.9	10.2
38.64	1772.9	1784.1	11.2
38.69	1781.2	1792.3	11.2
38.77	1798.0	1807.9	9.9
38.83	1810.0	1819.1	9.1
38.91	1824.2	1833.8	9.6
38.96	1832.1	1842.4	10.3
39.07	1854.0	1862.9	8.9
39.19	1877.4	1884.5	7.1
39.27	1894.6	1900.5	6.0
39.36	1910.5	1919.6	9.0
39.43	1927.5	1935.2	7.7
39.51	1949.0	1959.1	10.1
39.56	1963.7	1972.2	8.5
39.63	1977.5	1993.3	15.8
39.68	1989.4	2006.9	17.4
39.76	2001.5	2020.7	19.2
39.83	2019.5	2034.2	14.7
39.91	2031.3	2047.3	16.0

Table A-7. Computed 100-yr flood elevations and long-term changes after Seven Oaks Dam

Sec. No. River miles	Computed water-surface elevations, feet		
	Without dam (Case 1)	With dam (Case 8)	Difference
29.64	1055.1	1048.0	-7.1
29.80	1059.1	1054.0	-5.1
29.99	1067.0	1062.6	-4.4
30.12	1069.3	1065.7	-3.6
30.26	1074.0	1071.3	-2.7
30.38	1078.2	1074.6	-3.5
30.45	1081.3	1076.6	-4.7
30.56	1085.1	1080.9	-4.2
30.63	1086.6	1083.3	-3.3
30.75	1093.2	1089.4	-3.8
30.88	1096.1	1092.7	-3.4
31.02	1102.4	1098.6	-3.8
31.13	1105.7	1102.2	-3.6
31.23	1109.3	1106.5	-2.7
31.33	1114.1	1110.9	-3.2
31.47	1120.9	1116.9	-4.0
31.63	1126.2	1122.8	-3.4
31.71	1130.2	1127.1	-3.2
31.83	1137.2	1133.4	-3.8
31.96	1141.0	1137.4	-3.6
32.04	1145.5	1141.4	-4.1
32.17	1149.3	1146.4	-2.9
32.27	1154.9	1151.5	-3.4
32.37	1159.9	1157.1	-2.8
32.45	1163.4	1160.4	-3.1
32.55	1168.5	1165.9	-2.6
32.65	1175.5	1172.2	-3.2
32.77	1182.7	1180.4	-2.4
32.81	1188.5	1186.9	-1.7
32.99	1197.6	1195.0	-2.6
33.12	1202.6	1200.2	-2.4
33.17	1205.8	1204.1	-1.7
33.28	1211.2	1209.1	-2.1
33.31	1212.4	1210.0	-2.4
33.37	1217.7	1214.4	-3.2
33.44	1222.1	1218.9	-3.2
33.49	1225.3	1221.3	-4.0
33.54	1230.0	1225.2	-4.9
33.61	1232.9	1229.0	-3.9

Sec. No. River miles	Computed water-surface elevations, feet		
	Without dam (Case 1)	With dam (Case 8)	Difference
33.66	1239.0	1230.5	-8.5
33.72	1241.8	1235.5	-6.3
33.77	1246.0	1239.1	-6.9
33.81	1249.9	1245.7	-4.2
33.87	1254.8	1249.3	-5.5
33.94	1259.8	1252.6	-7.2
34.00	1265.7	1258.8	-6.9
34.09	1271.1	1264.0	-7.1
34.17	1276.8	1269.6	-7.2
34.27	1282.2	1274.8	-7.4
34.36	1287.4	1282.5	-4.9
34.39	1291.7	1289.0	-2.7
34.45	1295.7	1291.2	-4.5
34.51	1300.8	1297.0	-3.8
34.65	1311.1	1306.0	-5.0
34.70	1317.1	1311.0	-6.1
34.76	1321.6	1315.2	-6.3
34.81	1326.3	1319.1	-7.2
34.86	1330.9	1323.2	-7.7
34.91	1334.7	1329.3	-5.3
34.98	1341.8	1335.7	-6.1
35.04	1346.8	1339.0	-7.7
35.09	1351.8	1341.7	-10.0
35.15	1357.1	1347.9	-9.1
35.19	1361.4	1352.7	-8.7
35.29	1370.6	1362.2	-8.4
35.39	1380.5	1372.9	-7.6
35.51	1389.7	1383.5	-6.2
35.56	1395.2	1386.5	-8.6
35.61	1400.5	1392.6	-7.9
35.72	1409.7	1402.2	-7.5
35.81	1418.8	1410.5	-8.3
35.88	1423.8	1415.7	-8.1
35.95	1429.7	1421.9	-7.7
36.02	1436.0	1427.7	-8.3
36.06	1439.6	1436.6	-3.0
36.10	1443.5	1436.9	-6.5
36.15	1448.9	1439.4	-9.6
36.22	1457.5	1446.7	-10.8

Sec. No. River miles	Computed water-surface elevations, feet		
	Without dam (Case 1)	With dam (Case 8)	Difference
36.29	1462.4	1453.1	-9.4
36.36	1467.8	1458.5	-9.3
36.41	1475.3	1466.2	-9.1
36.48	1481.8	1474.2	-7.7
36.51	1486.7	1479.2	-7.5
36.57	1492.2	1487.2	-5.0
36.61	1497.4	1492.6	-4.8
36.67	1504.1	1500.5	-3.6
36.73	1510.9	1506.8	-4.2
36.81	1521.7	1515.1	-6.6
36.88	1528.7	1519.2	-9.5
36.98	1540.7	1538.2	-2.5
37.04	1548.5	1545.1	-3.4
37.09	1553.8	1550.9	-2.9
37.17	1562.4	1556.9	-5.5
37.24	1570.2	1565.6	-4.6
37.31	1578.8	1572.6	-6.2
37.36	1582.6	1574.7	-7.9
37.39	1589.3	1581.2	-8.1
37.45	1598.5	1585.8	-12.7
37.49	1605.3	1593.9	-11.4
37.56	1613.3	1600.3	-13.0
37.63	1621.4	1611.3	-10.1
37.67	1625.7	1614.8	-10.9
37.72	1631.5	1619.6	-11.8
37.79	1637.8	1626.4	-11.4
37.83	1645.4	1634.8	-10.6
37.91	1654.8	1643.7	-11.1
37.97	1664.4	1652.1	-12.3
38.04	1673.1	1655.9	-17.2
38.11	1680.9	1689.7	8.8
38.17	1689.0	1692.2	3.1
38.22	1694.9	1692.7	-2.2
38.30	1708.3	1701.7	-6.7
38.37	1716.0	1712.9	-3.0
38.47	1728.6	1728.2	-0.4
38.54	1740.1	1738.6	-1.4
38.61	1753.3	1748.0	-5.3

Sec. No. River miles	Computed water-surface elevations, feet		
	Without dam (Case 1)	With dam (Case 8)	Difference
38.71	1777.8	1766.6	-11.2
38.79	1791.4	1777.3	-14.1
38.83	1803.9	1783.7	-20.2
38.86	1810.3	1789.2	-21.1
38.92	1819.2	1795.4	-23.8
38.97	1827.9	1808.5	-19.4
39.05	1838.4	1818.4	-20.0
39.10	1843.6	1824.3	-19.3
39.15	1851.9	1836.2	-15.7
39.18	1865.8	1848.7	-17.1
39.24	1870.5	1853.2	-17.3
39.35	1881.6	1861.4	-20.3
39.42	1887.5	1866.2	-21.3
39.49	1894.7	1884.1	-10.6
The following sections are along Mill Creek			
38.22	1705.9	1713.4	7.5
38.28	1716.2	1723.1	6.8
38.34	1726.3	1733.9	7.6
38.44	1742.8	1749.8	7.0
38.52	1758.7	1763.9	5.2
38.60	1773.9	1776.7	2.8
38.64	1785.2	1784.9	-0.3
38.69	1793.7	1792.6	-1.1
38.77	1809.1	1806.8	-2.3
38.83	1820.1	1817.4	-2.7
38.91	1835.1	1831.8	-3.2
38.96	1843.6	1840.0	-3.6
39.07	1863.9	1859.0	-5.0
39.19	1885.5	1883.2	-2.3
39.27	1901.5	1900.3	-1.1
39.36	1920.3	1918.6	-1.7
39.43	1935.9	1934.1	-1.9
39.51	1959.7	1956.6	-3.1
39.56	1972.9	1972.6	-0.3
39.63	1993.7	1997.0	3.3
39.68	2007.6	2019.1	11.4
39.76	2022.2	2036.0	13.8
39.83	2036.2	2048.4	12.3
39.91	2048.5	2059.6	11.1

Table A-8. Computed 50-yr flood elevations and long-term changes after Seven Oaks Dam

Sec. No. River miles	Computed water-surface elevations, feet		
	Without dam (Case 4)	With dam (Case 10)	Difference
29.64	1050.4	1047.3	-3.1
29.80	1055.1	1052.0	-3.1
29.99	1065.1	1061.6	-3.5
30.12	1068.1	1065.1	-3.0
30.26	1072.9	1069.9	-3.1
30.38	1076.8	1073.7	-3.2
30.45	1079.5	1075.9	-3.6
30.56	1083.4	1079.7	-3.7
30.63	1085.5	1082.8	-2.7
30.75	1090.5	1087.7	-2.8
30.88	1095.5	1092.5	-3.0
31.02	1100.6	1097.1	-3.5
31.13	1104.3	1101.2	-3.1
31.23	1107.4	1105.6	-1.8
31.33	1111.9	1109.8	-2.1
31.47	1118.3	1115.6	-2.7
31.63	1124.7	1121.9	-2.8
31.71	1127.8	1126.0	-1.8
31.83	1134.8	1132.1	-2.7
31.96	1140.1	1136.4	-3.7
32.04	1143.8	1139.6	-4.2
32.17	1147.8	1144.7	-3.1
32.27	1152.6	1150.9	-1.7
32.37	1158.0	1155.9	-2.0
32.45	1161.9	1158.8	-3.1
32.55	1165.8	1164.8	-1.0
32.65	1172.5	1171.8	-0.7
32.77	1177.7	1177.1	-0.6
32.81	1185.5	1184.6	-0.9
32.99	1193.4	1193.7	0.3
33.12	1199.9	1199.3	-0.6
33.17	1203.8	1203.3	-0.5
33.28	1208.5	1207.2	-1.3
33.31	1210.4	1208.3	-2.2
33.37	1215.0	1212.3	-2.7
33.44	1219.9	1217.3	-2.6
33.49	1223.0	1219.9	-3.1
33.54	1227.5	1222.7	-4.8
33.61	1232.9	1227.0	-6.0

Sec. No. River miles	Computed water-surface elevations, feet		
	Without dam (Case 4)	With dam (Case 10)	Difference
33.66	1236.1	1229.5	-6.6
33.72	1240.1	1232.6	-7.5
33.77	1243.8	1236.8	-7.0
33.81	1248.3	1241.1	-7.2
33.87	1253.0	1246.7	-6.3
33.94	1257.0	1251.0	-6.0
34.00	1262.9	1256.0	-6.8
34.09	1267.5	1261.5	-5.9
34.17	1272.7	1266.5	-6.1
34.27	1279.4	1274.1	-5.3
34.36	1283.5	1280.1	-3.4
34.39	1288.5	1284.9	-3.6
34.45	1291.8	1288.8	-3.1
34.51	1300.2	1294.5	-5.7
34.65	1310.6	1305.9	-4.7
34.70	1314.4	1308.5	-5.9
34.76	1321.1	1312.7	-8.4
34.81	1323.4	1316.7	-6.7
34.86	1327.7	1320.3	-7.4
34.91	1332.4	1325.5	-6.9
34.98	1338.3	1331.5	-6.7
35.04	1345.0	1336.5	-8.5
35.09	1348.0	1340.3	-7.7
35.15	1356.2	1346.4	-9.7
35.19	1359.3	1351.6	-7.7
35.29	1366.5	1360.0	-6.5
35.39	1375.9	1370.7	-5.2
35.51	1384.4	1380.8	-3.7
35.56	1390.9	1385.2	-5.7
35.61	1394.8	1389.6	-5.1
35.72	1404.4	1399.0	-5.4
35.81	1413.1	1406.5	-6.6
35.88	1421.0	1413.4	-7.7
35.95	1426.4	1420.4	-6.1
36.02	1433.2	1423.3	-9.9
36.06	1436.8	1429.3	-7.5
36.10	1441.7	1434.8	-6.9
36.15	1446.2	1437.6	-8.7
36.22	1453.9	1444.2	-9.8

Sec. No. River miles	Computed water-surface elevations, feet		
	Without dam (Case 4)	With dam (Case 10)	Difference
36.29	1461.0	1451.1	-10.0
36.36	1465.8	1456.6	-9.2
36.41	1473.4	1463.8	-9.7
36.48	1479.2	1471.8	-7.4
36.51	1485.0	1476.7	-8.3
36.57	1491.4	1482.8	-8.6
36.61	1496.4	1489.4	-7.0
36.67	1503.3	1496.3	-7.0
36.73	1507.6	1503.2	-4.4
36.81	1517.9	1512.0	-5.9
36.88	1525.3	1518.1	-7.3
36.98	1537.8	1533.9	-3.9
37.04	1547.6	1544.1	-3.5
37.09	1551.6	1546.2	-5.4
37.17	1557.5	1554.3	-3.2
37.24	1569.6	1563.0	-6.6
37.31	1576.4	1567.8	-8.6
37.36	1580.5	1573.0	-7.5
37.39	1586.4	1577.4	-8.9
37.45	1594.9	1584.6	-10.3
37.49	1601.6	1592.1	-9.5
37.56	1607.3	1600.3	-7.0
37.63	1616.0	1606.3	-9.7
37.67	1622.2	1612.5	-9.7
37.72	1626.3	1617.6	-8.7
37.79	1634.8	1623.9	-10.9
37.83	1641.3	1631.9	-9.5
37.91	1653.3	1640.8	-12.5
37.97	1662.7	1649.3	-13.4
38.04	1671.2	1653.5	-17.7
38.11	1676.6	1689.3	12.7
38.17	1683.1	1691.4	8.4
38.22	1692.9	1692.2	-0.7
38.30	1702.6	1698.8	-3.8
38.37	1712.6	1712.6	0.0
38.47	1724.8	1727.7	2.9
38.54	1736.5	1737.3	0.8
38.61	1750.1	1746.8	-3.3
38.66	1762.7	1756.8	-5.8

Sec. No. River miles	Computed water-surface elevations, feet		
	Without dam (Case 4)	With dam (Case 10)	Difference
38.71	1773.5	1765.2	-8.3
38.79	1787.6	1775.7	-11.9
38.83	1802.1	1781.6	-20.5
38.86	1809.8	1787.9	-21.9
38.92	1817.4	1794.3	-23.1
38.97	1827.2	1807.2	-20.1
39.05	1834.0	1817.0	-17.0
39.10	1840.1	1823.2	-16.8
39.15	1849.3	1835.3	-14.0
39.18	1861.7	1848.0	-13.7
39.24	1867.9	1851.6	-16.3
39.35	1877.6	1860.7	-16.9
39.42	1883.7	1864.9	-18.7
39.49	1892.9	1883.5	-9.4
The following sections are along Mill Creek			
38.22	1704.7	1712.3	7.6
38.28	1714.7	1722.2	7.5
38.34	1725.2	1732.8	7.6
38.44	1741.7	1748.4	6.8
38.52	1757.4	1762.5	5.1
38.60	1772.9	1775.3	2.4
38.64	1784.1	1783.1	-1.0
38.69	1792.3	1790.8	-1.5
38.77	1807.9	1805.3	-2.6
38.83	1819.1	1816.1	-3.0
38.91	1833.8	1830.5	-3.3
38.96	1842.4	1838.5	-3.8
39.07	1862.9	1857.7	-5.2
39.19	1884.5	1882.1	-2.4
39.27	1900.5	1899.2	-1.4
39.36	1919.6	1917.2	-2.3
39.43	1935.2	1932.3	-2.9
39.51	1959.1	1954.1	-5.0
39.56	1972.2	1970.1	-2.1
39.63	1993.3	1995.6	2.3
39.68	2006.9	2017.6	10.7
39.76	2020.7	2034.2	13.5
39.83	2034.2	2045.6	11.4
39.91	2047.3	2058.4	11.1

Santa Ana River
 Water-Surface and Channel-Bed Profiles
 During flood series

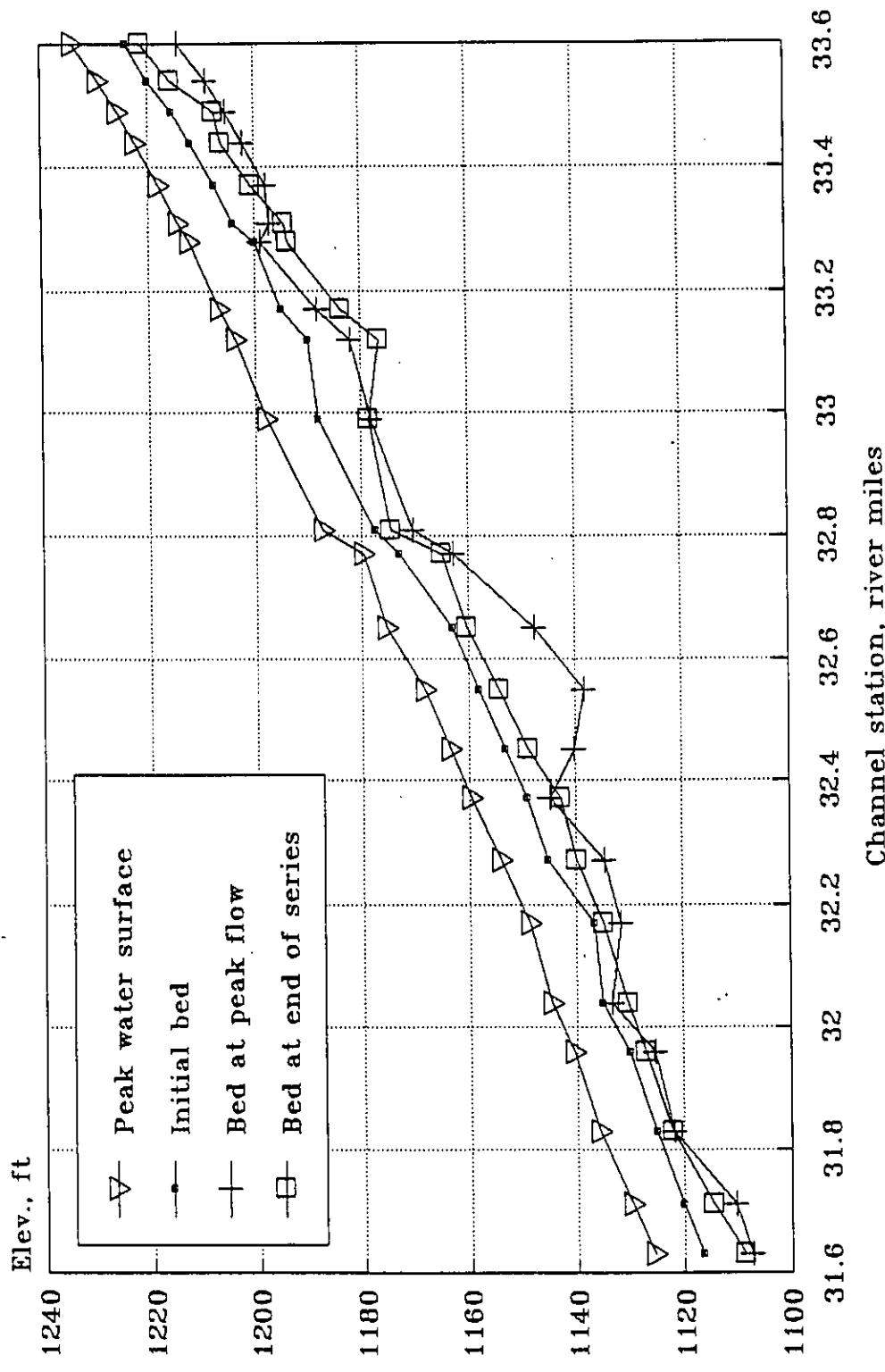


Fig. A-1. Water-surface profile at peak flow and channel-bed changes during the flood series - before Seven Oaks Dam

Santa Ana River
Water-Surface and Channel-Bed Profiles
During flood series

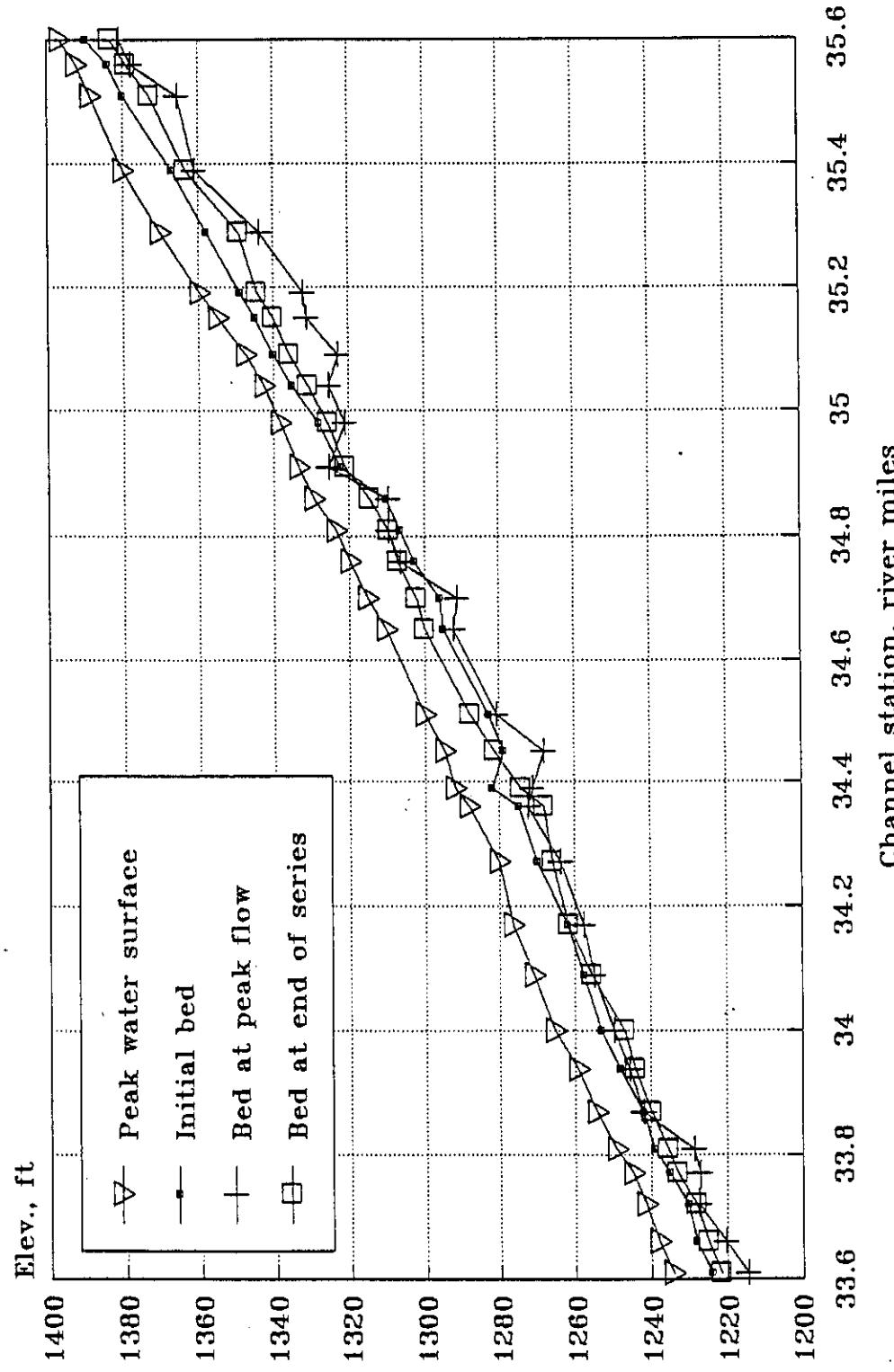


Fig. A-1 (continued). Water-surface profile at peak flow and channel-bed changes during the flood series - before Seven Oaks Dam

Santa Ana River
 Water-Surface and Channel-Bed Profiles
 During flood series

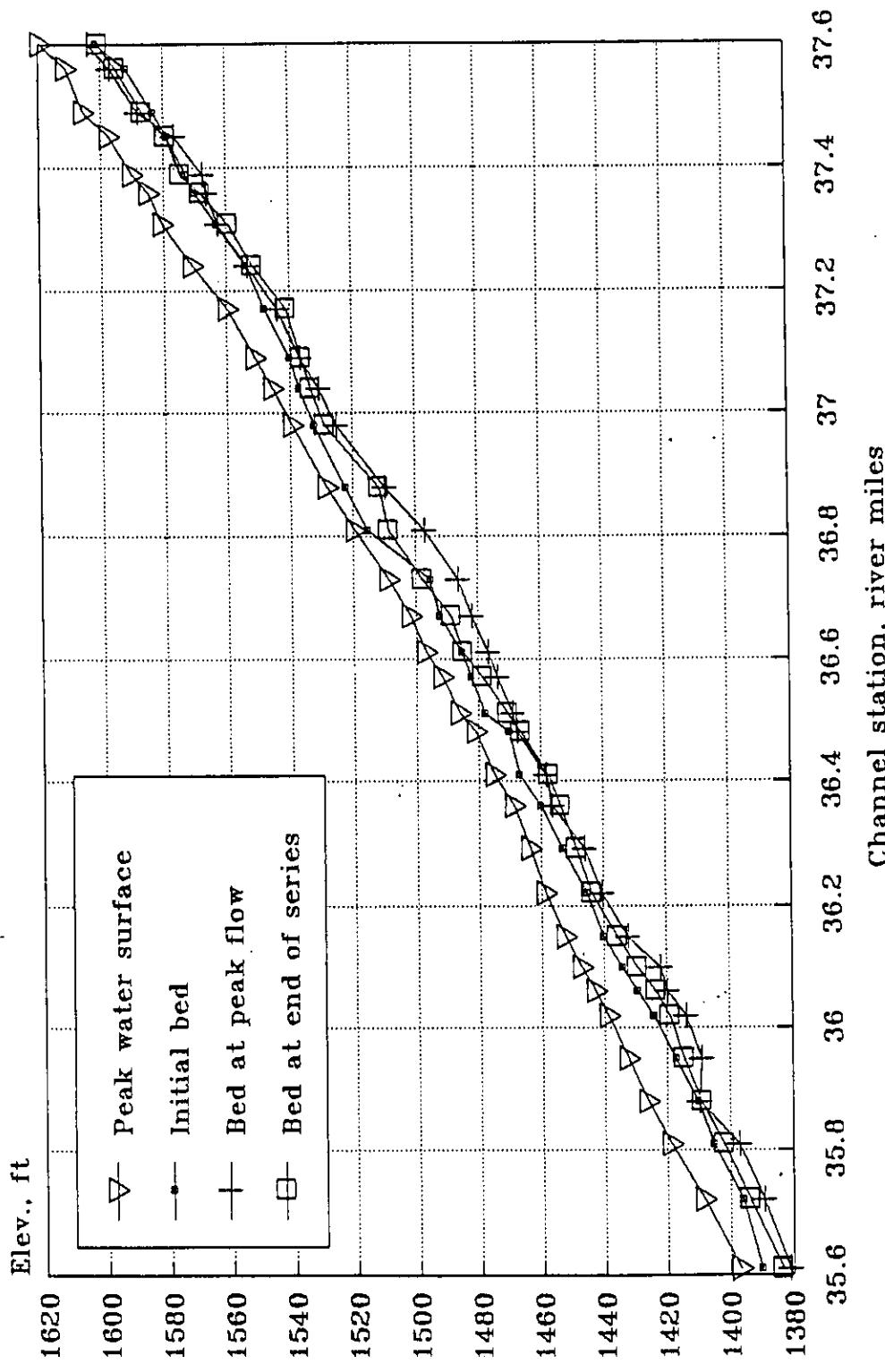


Fig. A-1 (continued). Water-surface profile at peak flow and channel-bed changes during the flood series - before Seven Oaks Dam

Santa Ana River
Water-Surface and Channel-Bed Profiles
During flood series

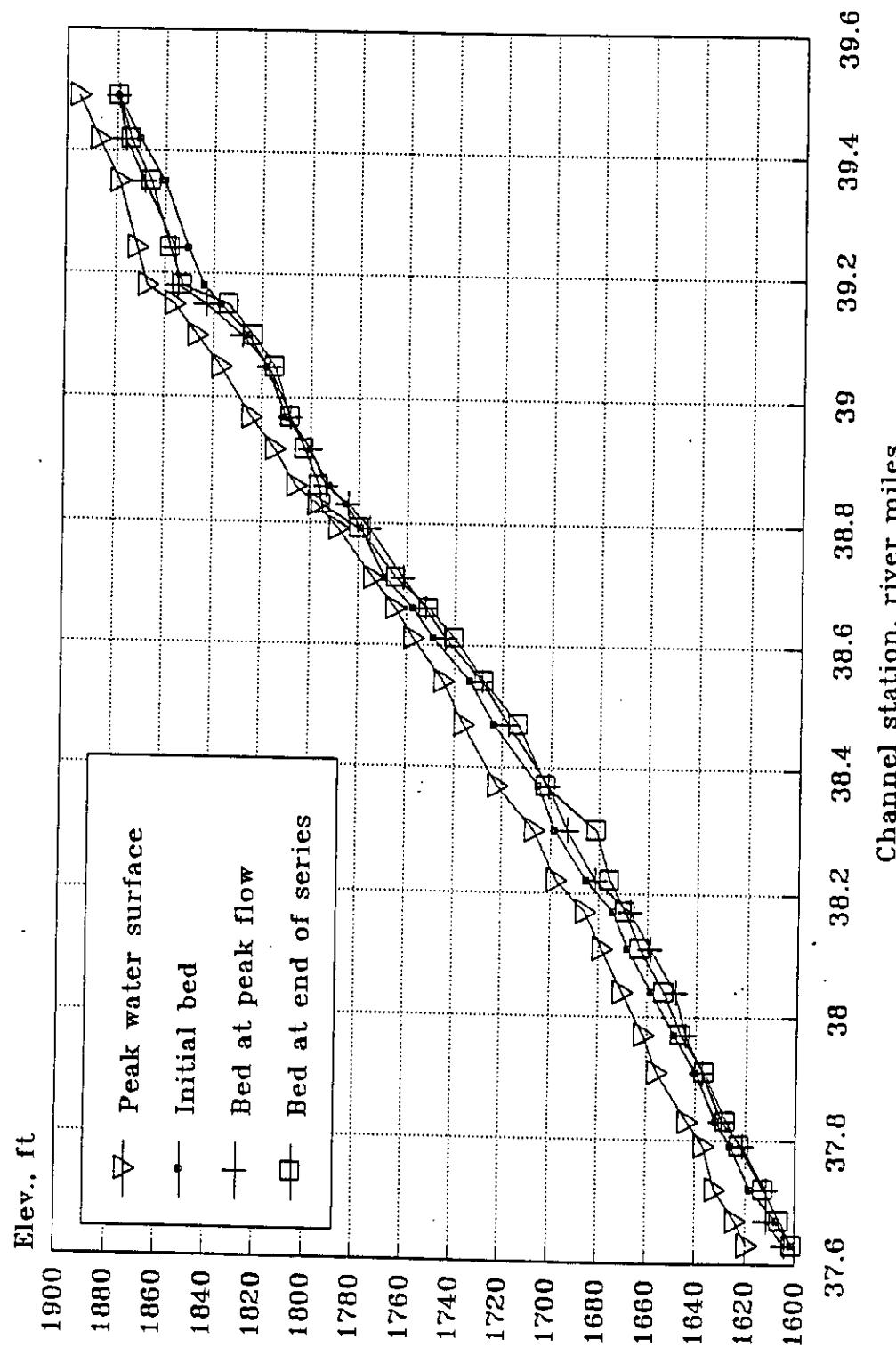


Fig. A-1 (continued). Water-surface profile at peak flow and channel-bed changes during the flood series - before Seven Oaks Dam

Santa Ana River
Water-Surface and Channel-Bed Profiles
During Flood Series

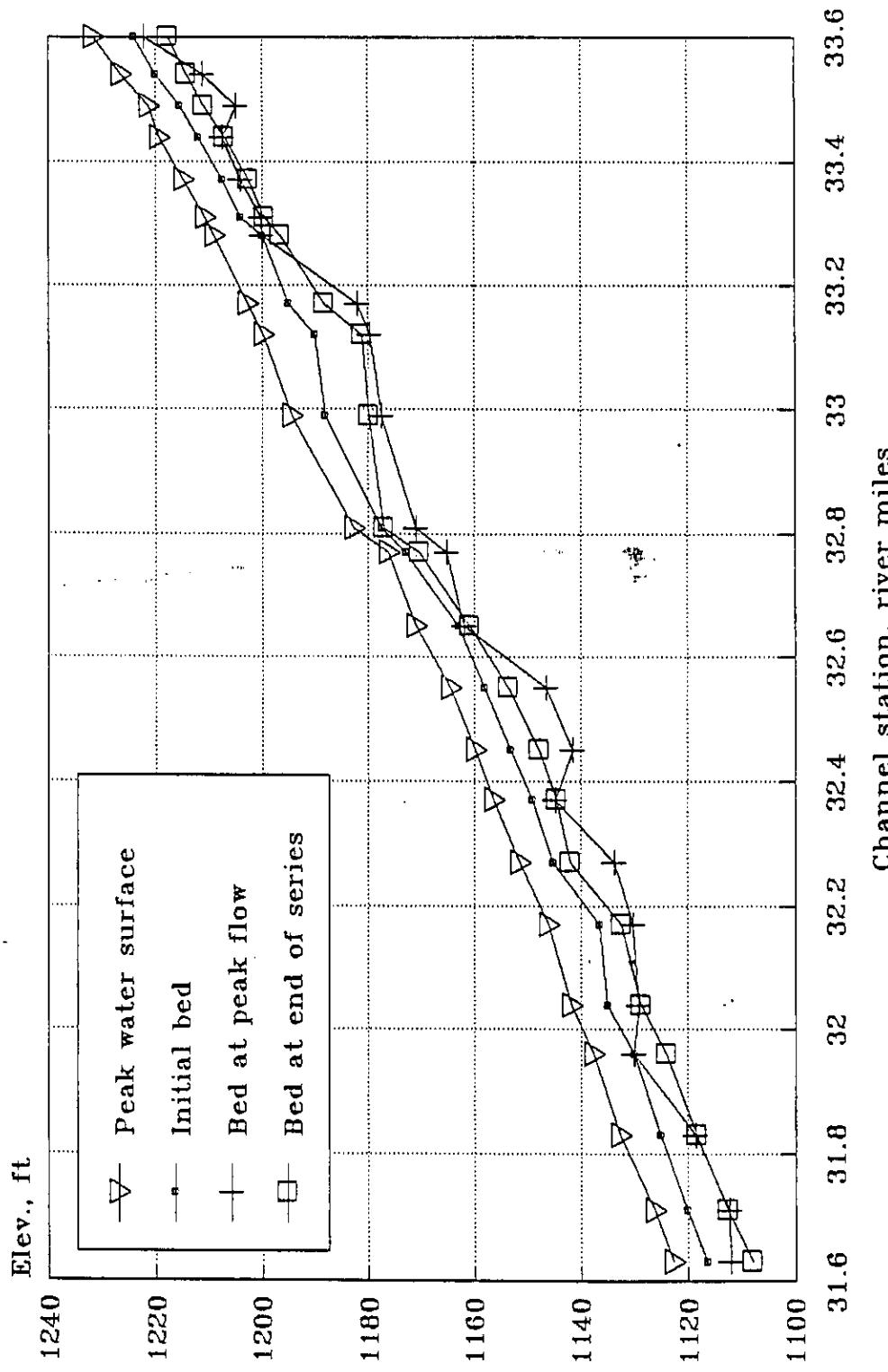


Fig. A-2. Water-surface profile at peak flow and channel-bed changes during the flood series - after Seven Oaks Dam

Santa Ana River
 Water-Surface and Channel-Bed Profiles
 During Flood Series

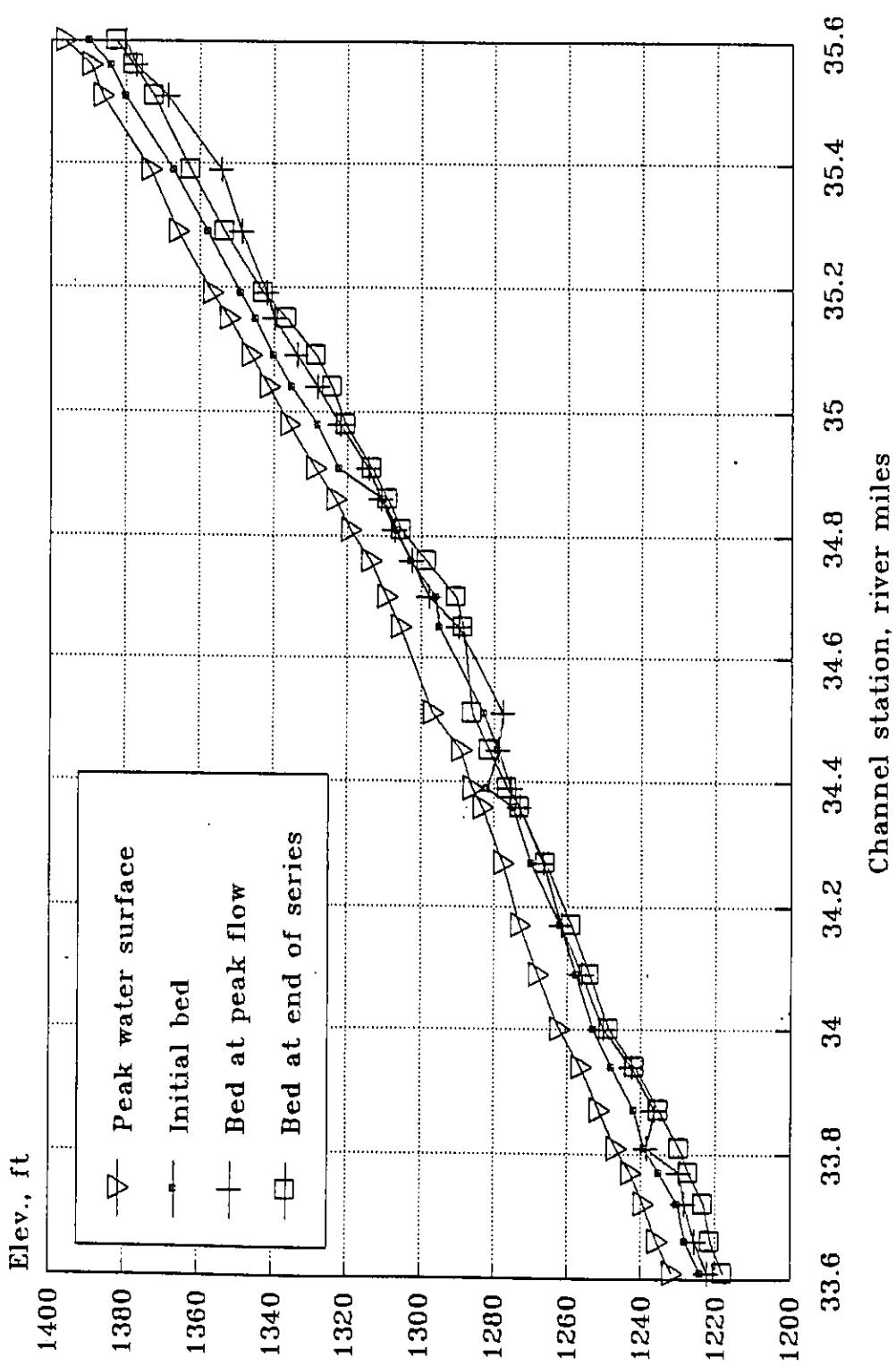


Fig. A-2 (continued). Water-surface profile at peak flow and channel-bed changes during the flood series - after Seven Oaks Dam

Santa Ana River
Water-Surface and Channel-Bed Profiles
During Flood Series

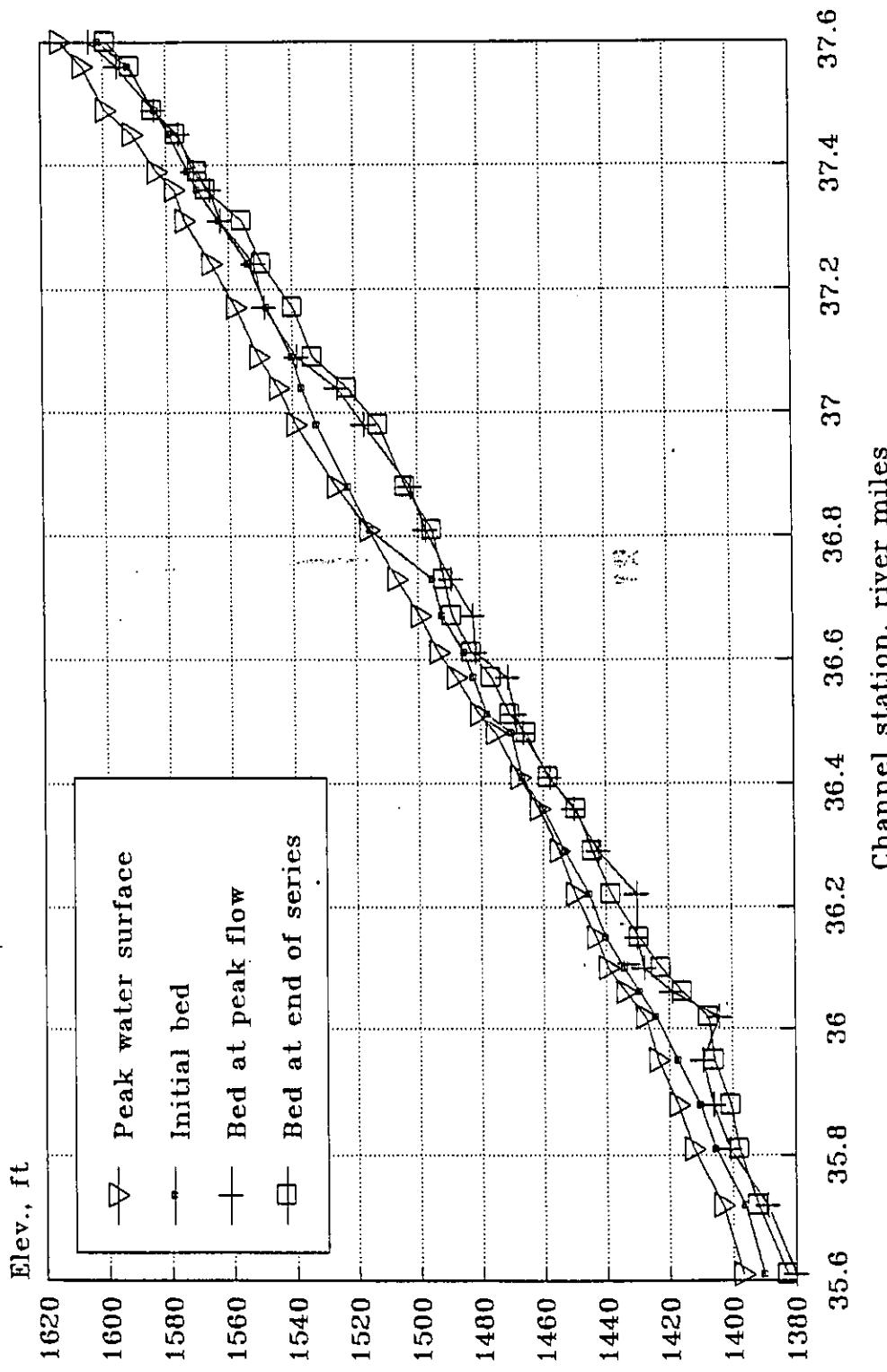


Fig. A-2 (continued). Water-surface profile at peak flow and channel-bed changes during the flood series - after Seven Oaks Dam

Santa Ana River
Water-Surface and Channel-Bed Profiles
During Flood Series

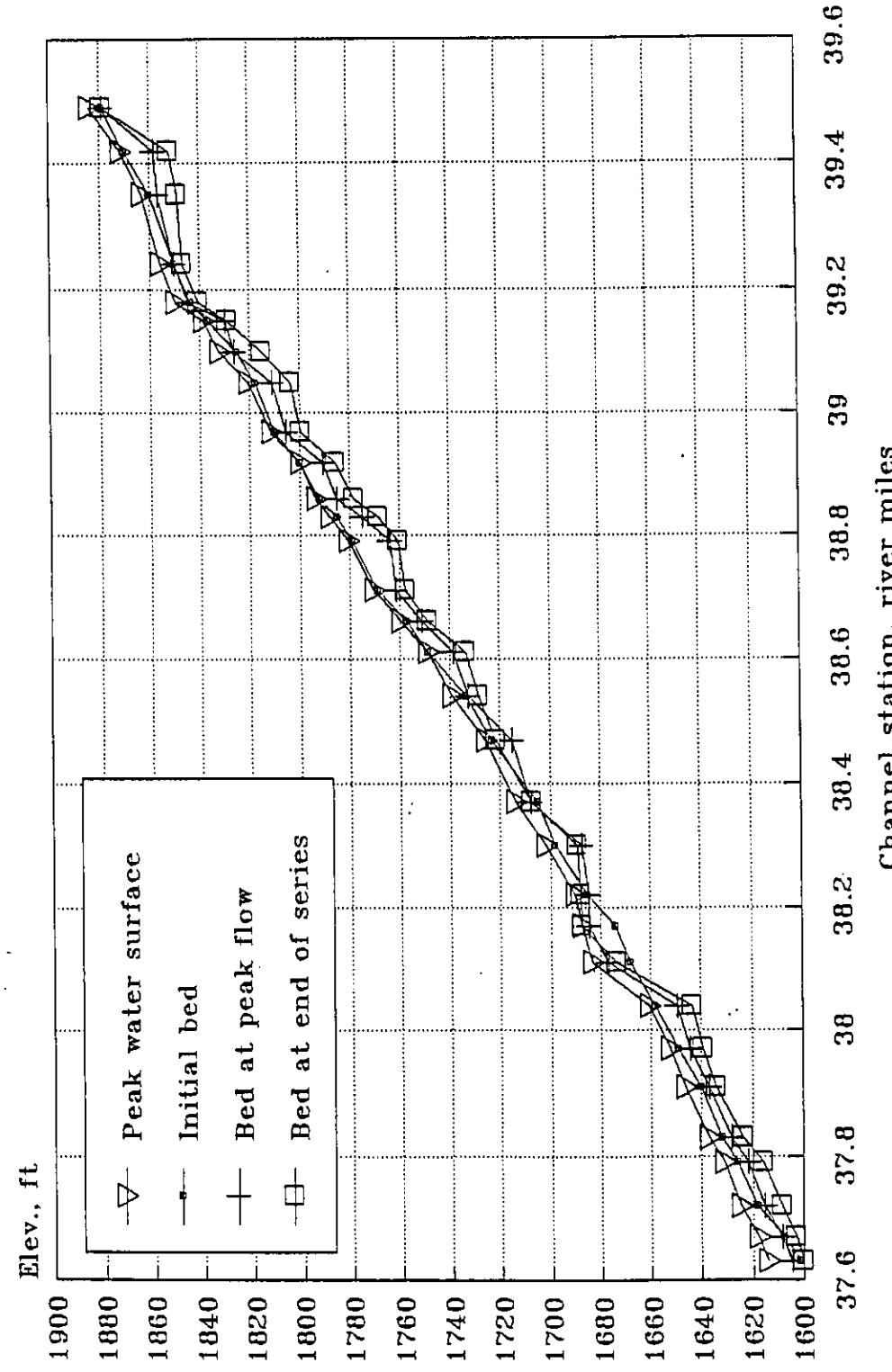


Fig. A-2 (continued). Water-surface profile at peak flow and channel-bed changes during the flood series - after Seven Oaks Dam

Santa Ana River/Mill Creek
Water-Surface and Channel-Bed Profiles
During Flood Series

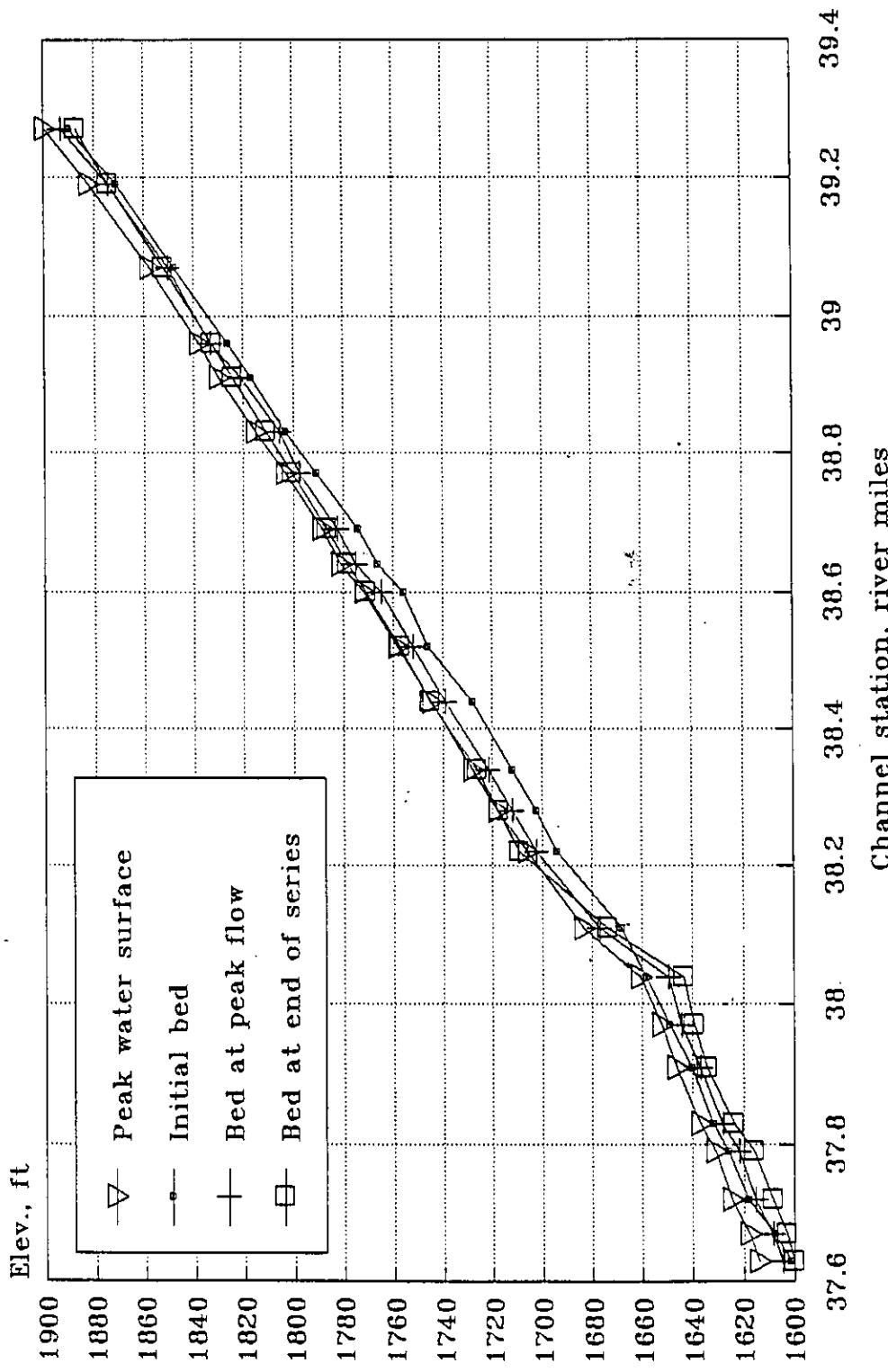
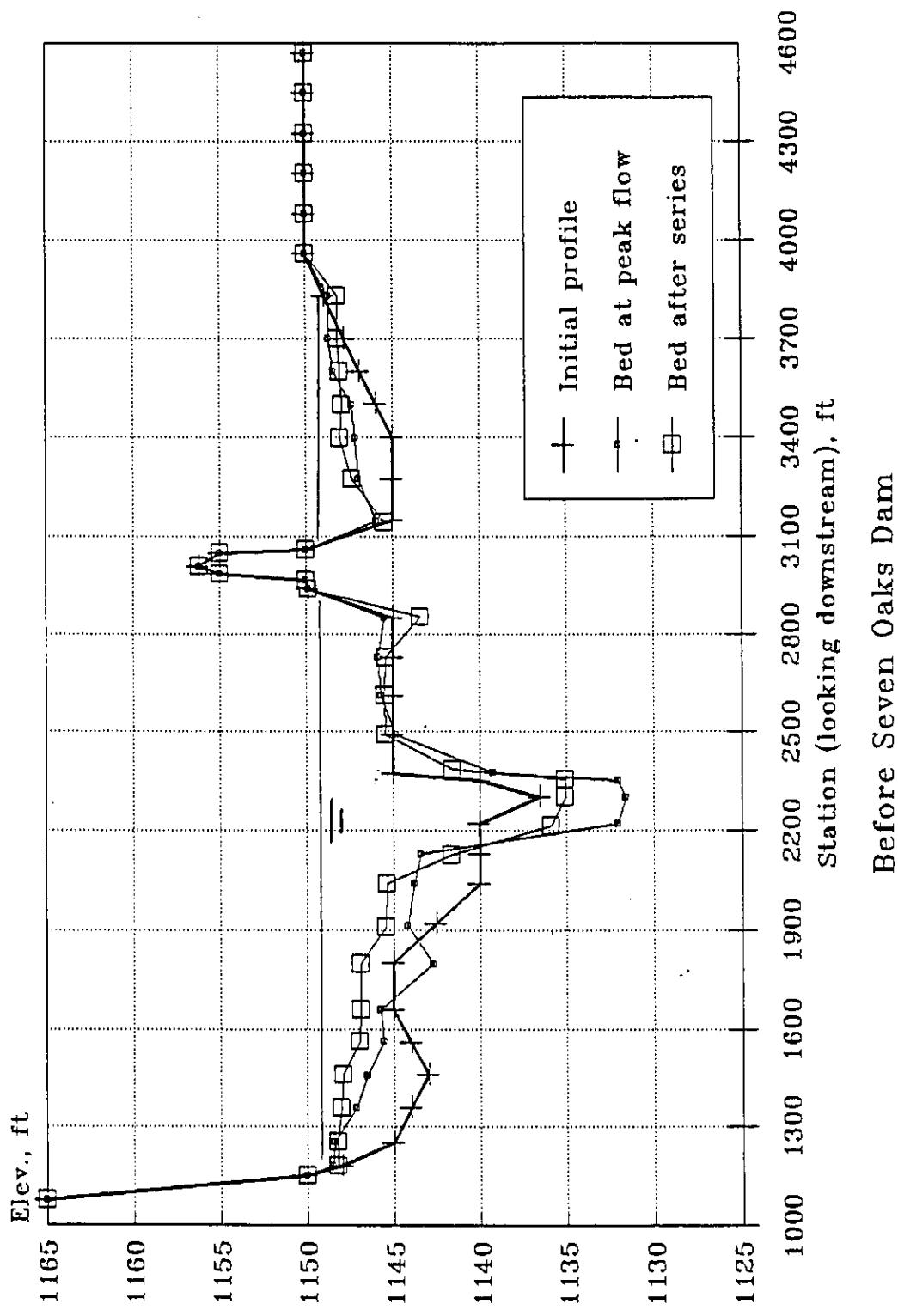


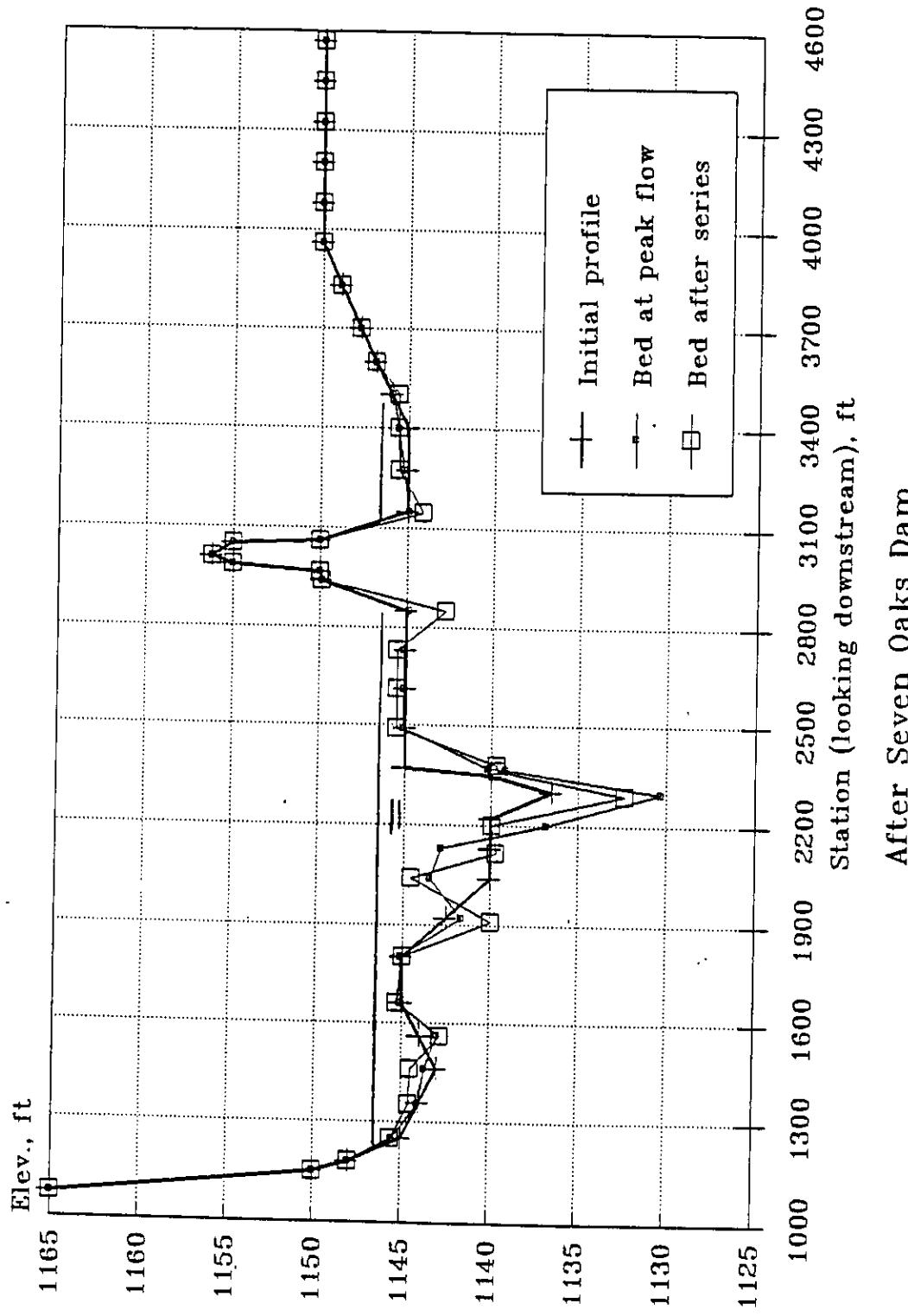
Fig. A-2 (continued). Water-surface profile at peak flow and channel-bed changes during the flood series - after Seven Oaks Dam

Fig. A-3. Sample cross-sectional changes during 100-yr flood series
before and after Seven Oaks Dam.
The horizontal lines are peak water-surface profiles.

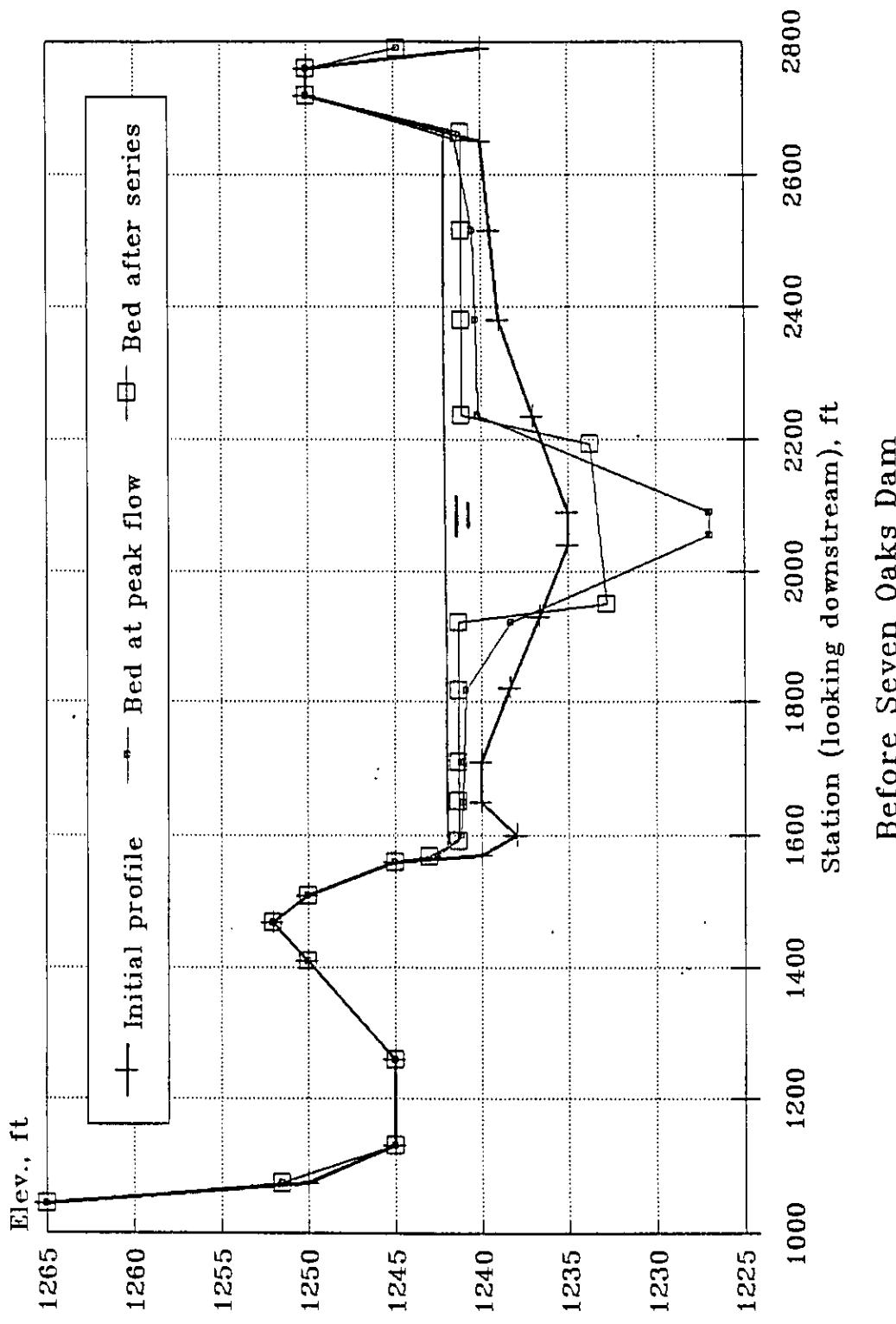
Simulated Changes During Flood Series
at Sec. 32.17



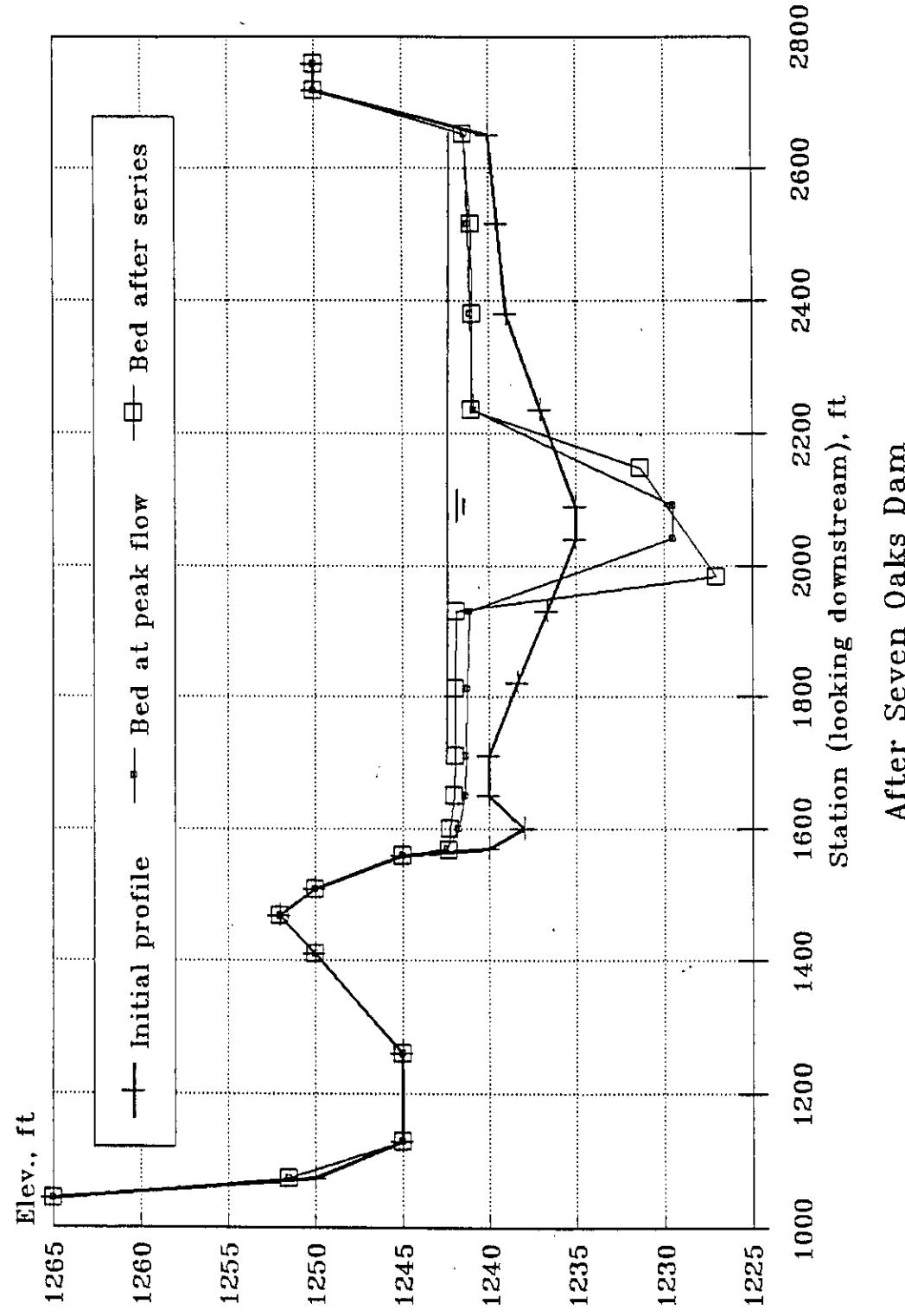
Simulated Changes During Flood Series
at Sec. 32.17



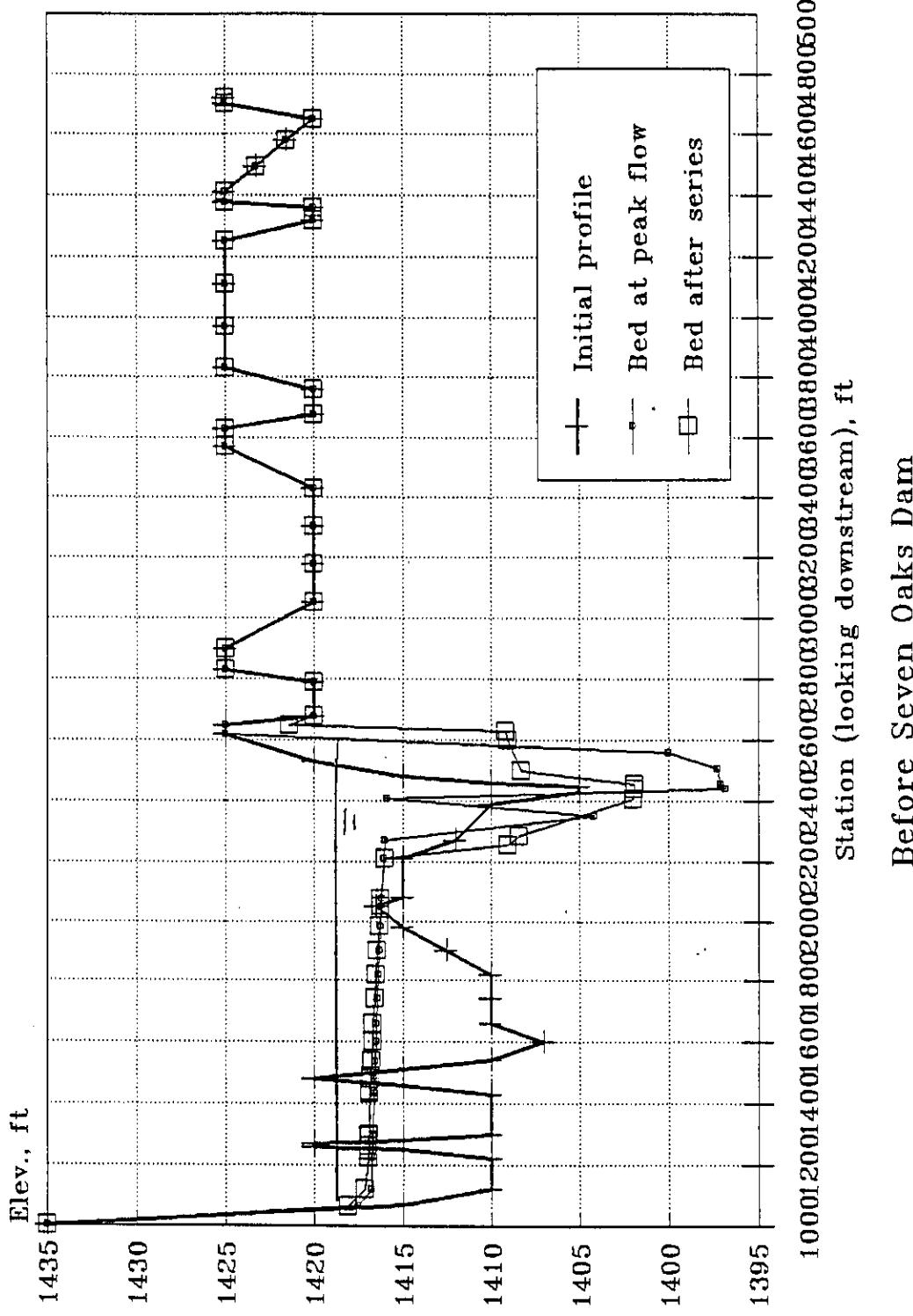
Simulated Changes During Flood Series
at Sec. 33.77



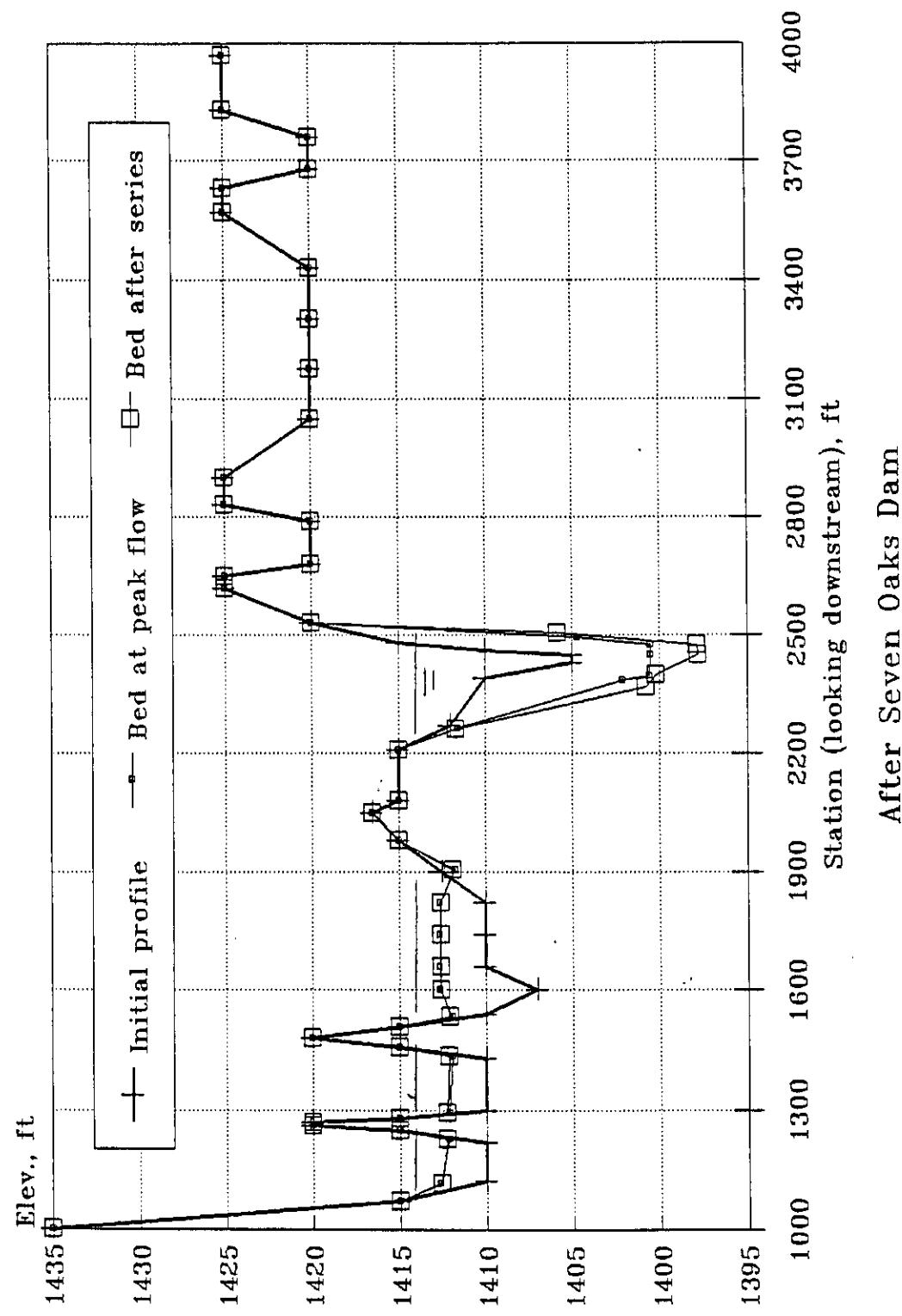
Simulated Changes During Flood Series
at Sec. 33.77



Simulated Changes During Flood Series
at Sec. 35.81

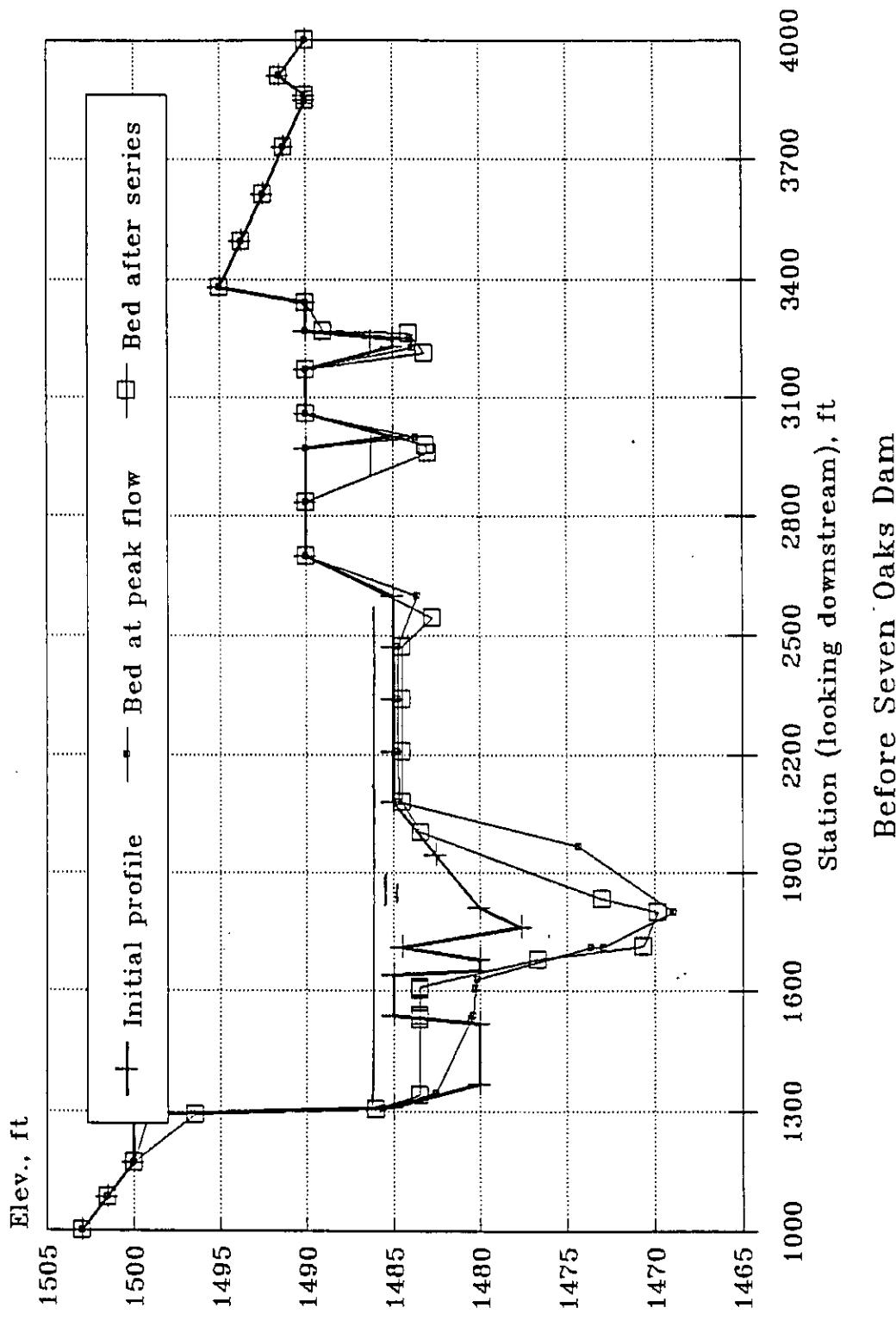


Simulated Changes During Flood Series
at Sec. 35.81

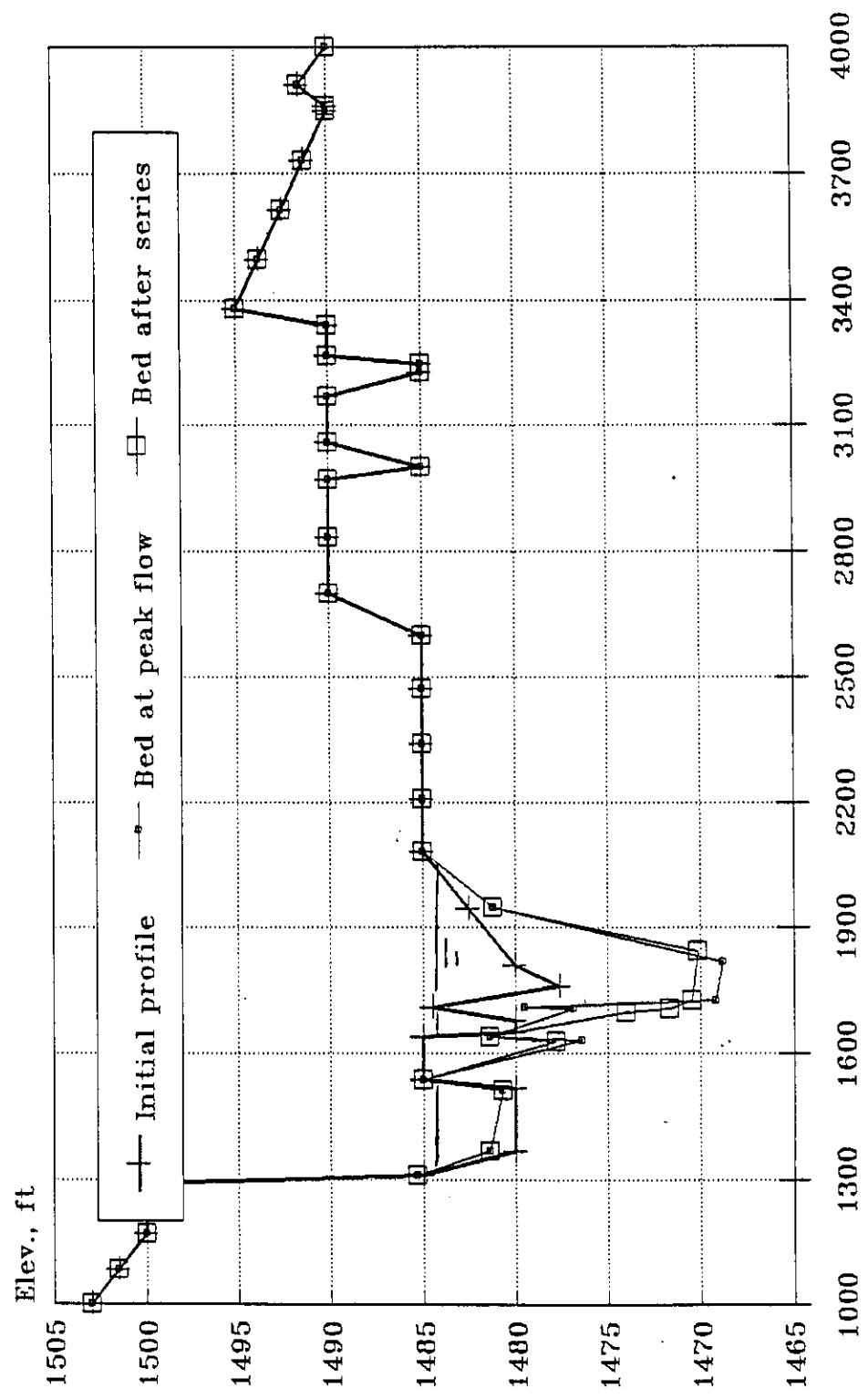


After Seven Oaks Dam

Simulated Changes During Flood Series
at Sec. 36.51

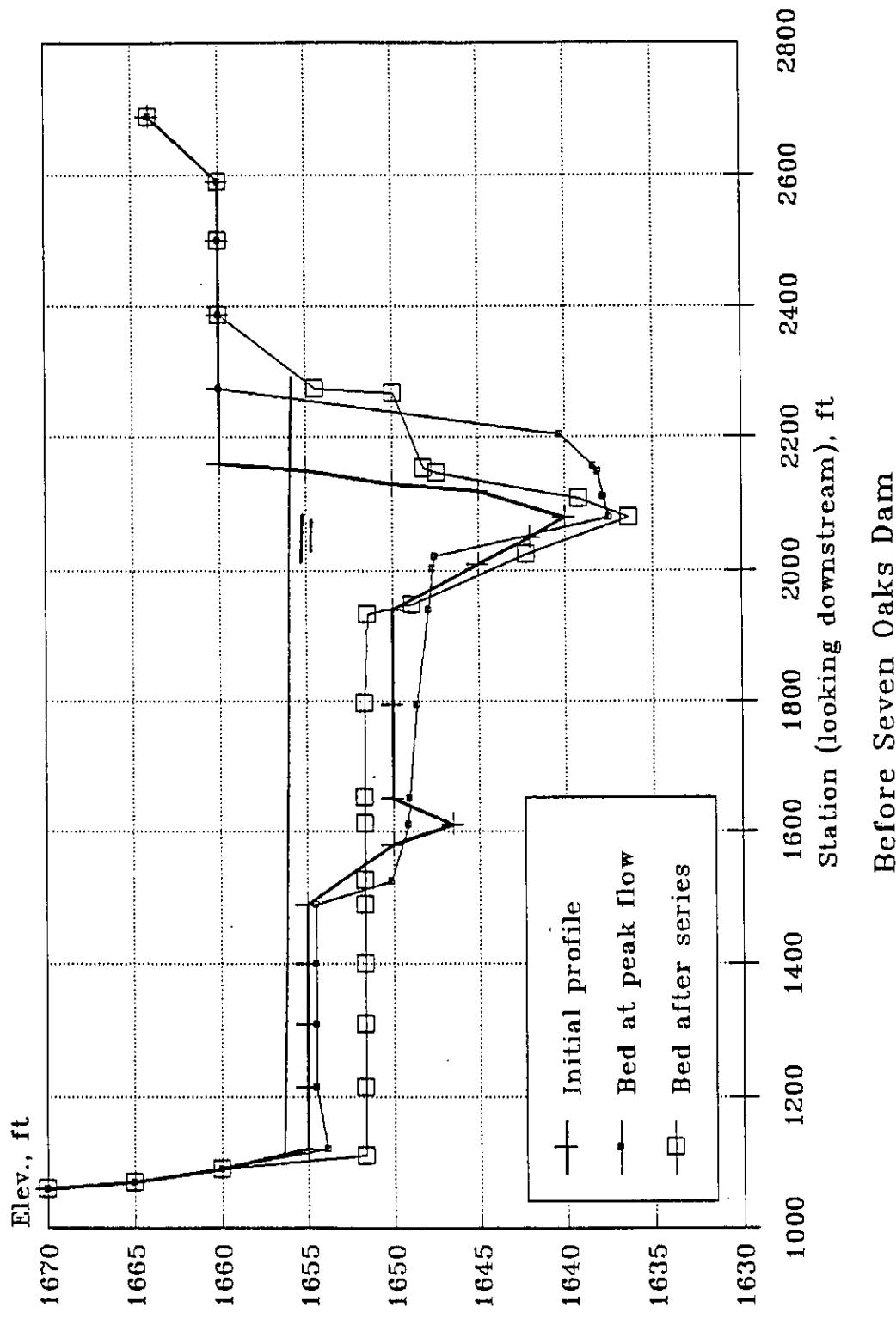


Simulated Changes During Flood Series
at Sec. 36.51



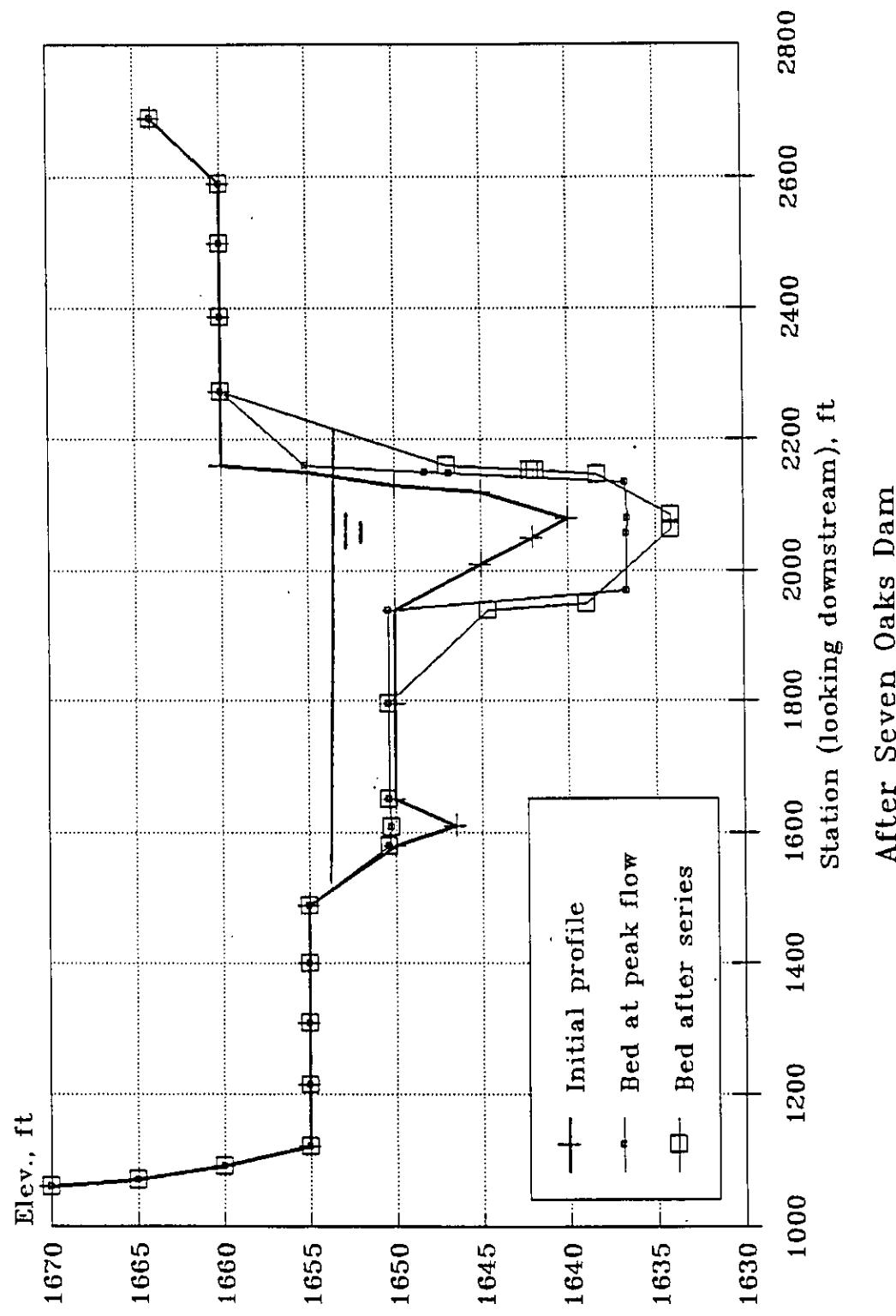
After Seven Oaks Dam

Simulated Changes During Flood Series
at Sec. 37.91



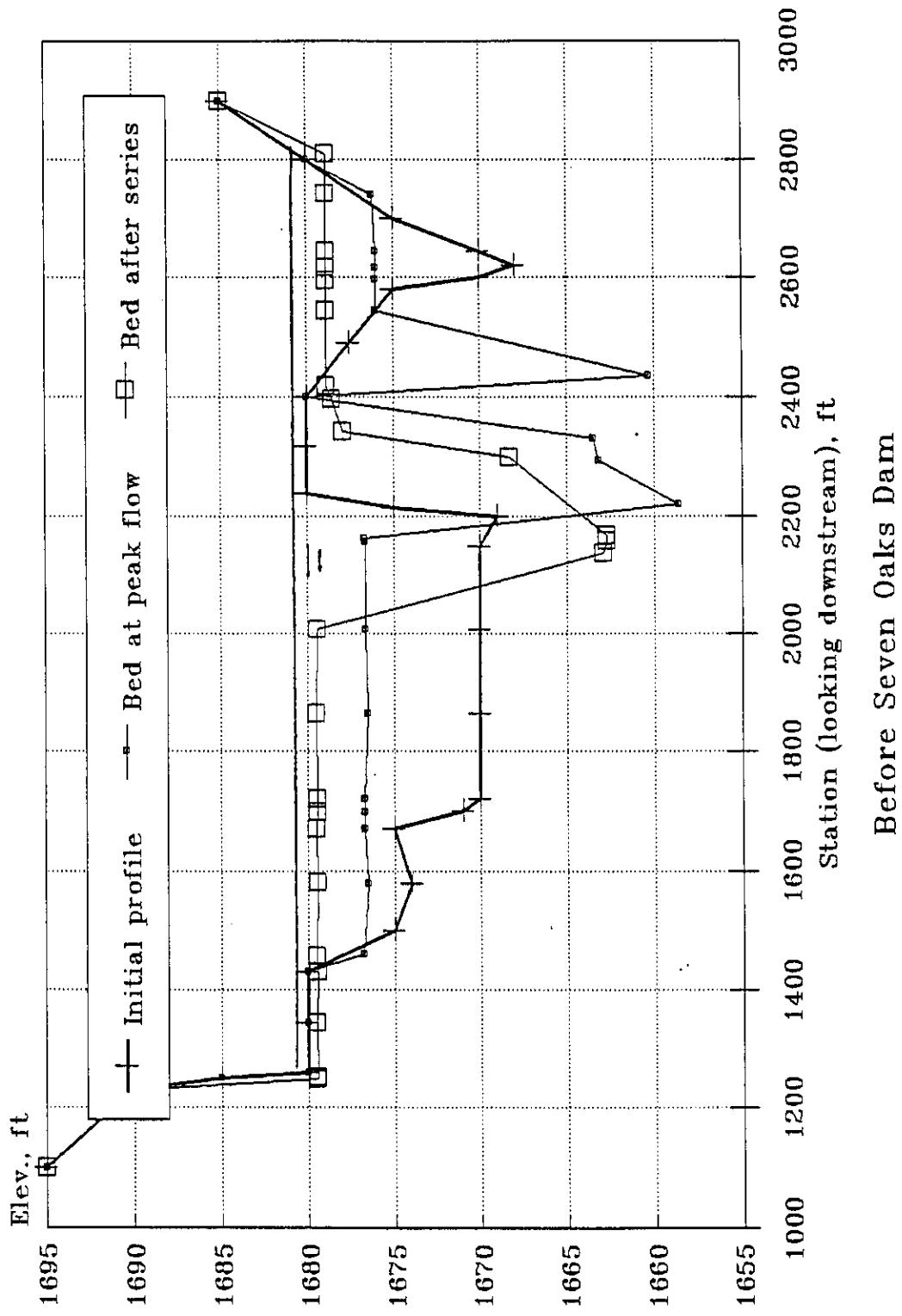
Before Seven Oaks Dam

Simulated Changes During Flood Series
at Sec. 37.91



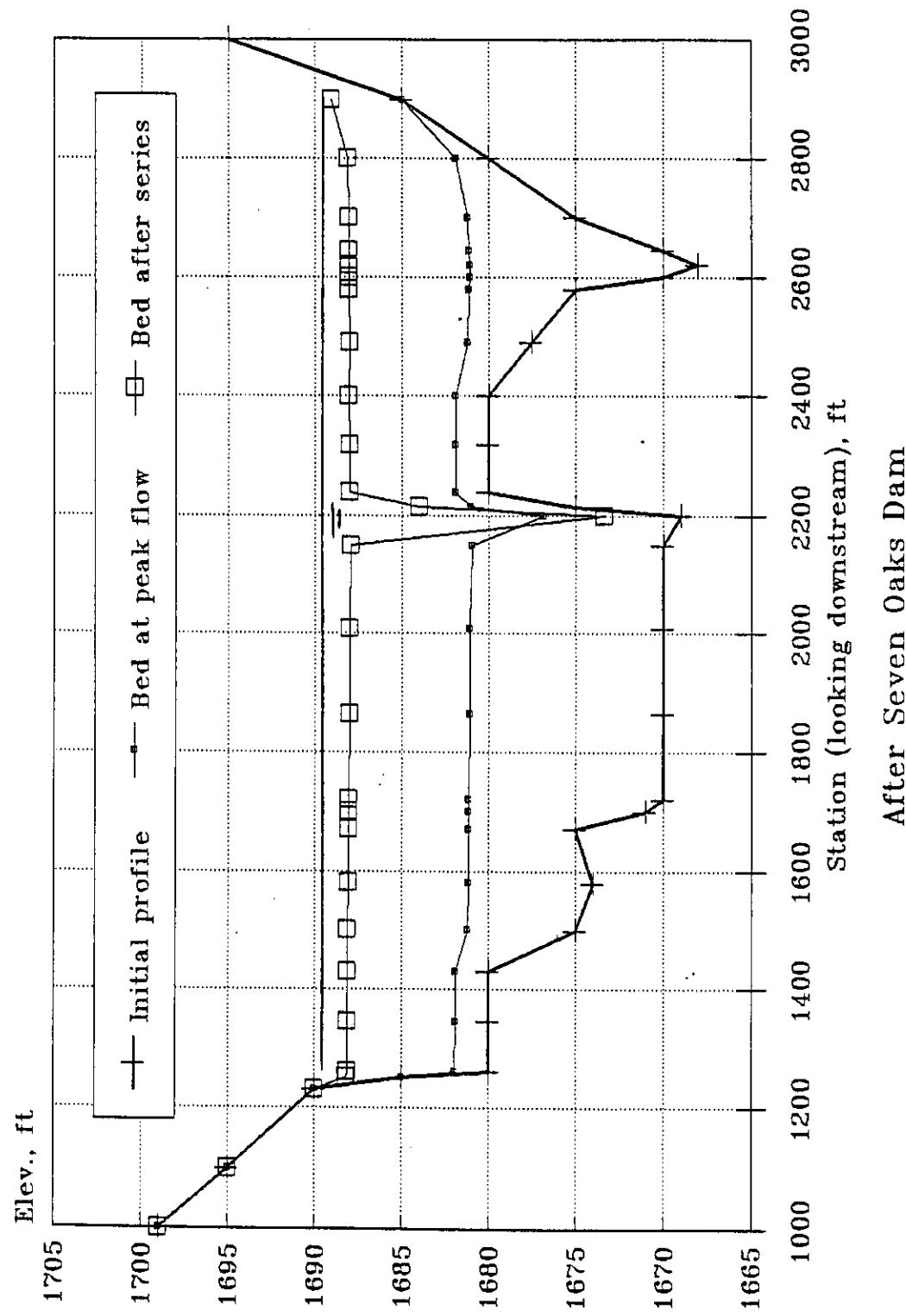
After Seven Oaks Dam

Simulated Changes During Flood Series
at Sec. 38.11

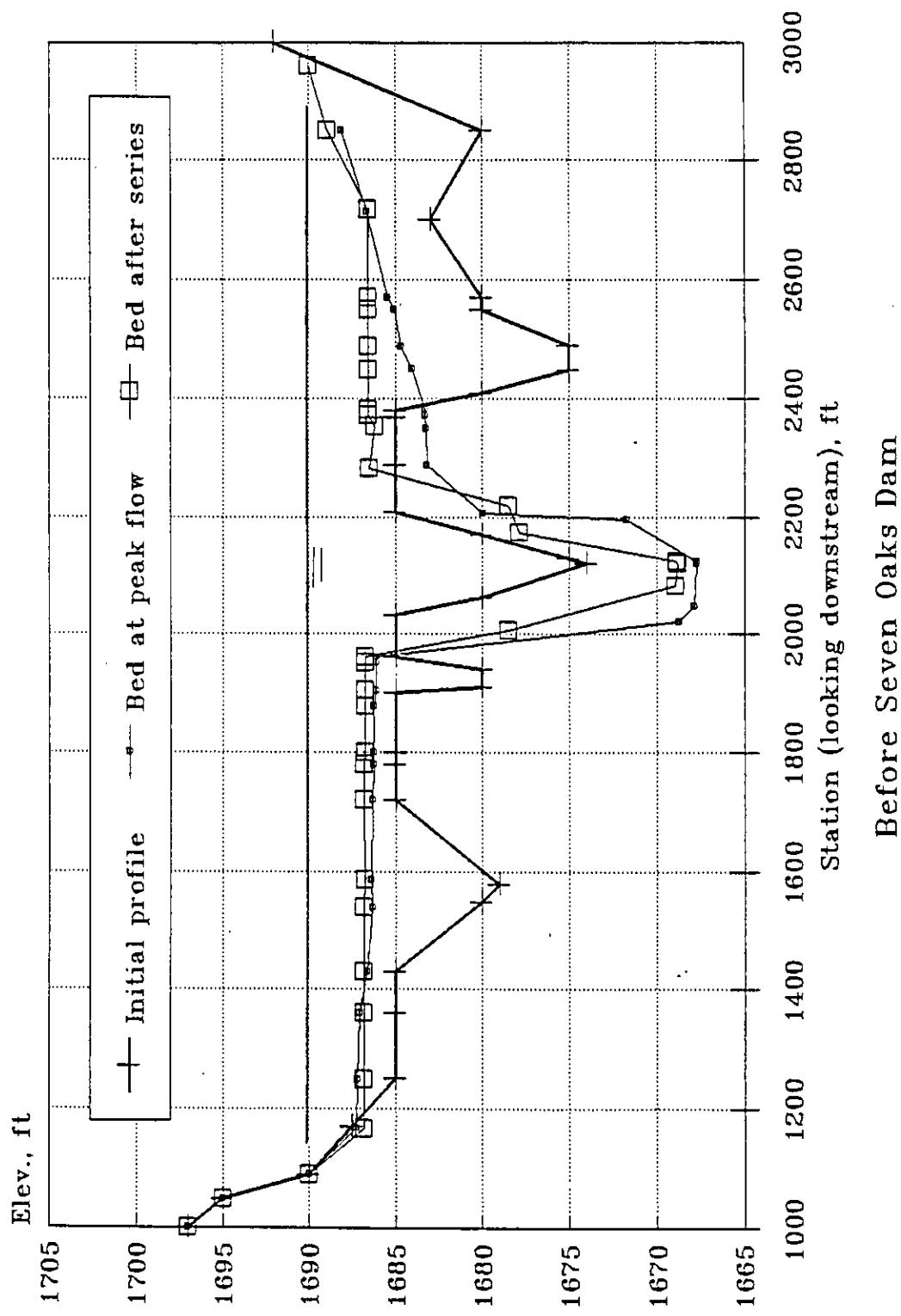


Before Seven Oaks Dam

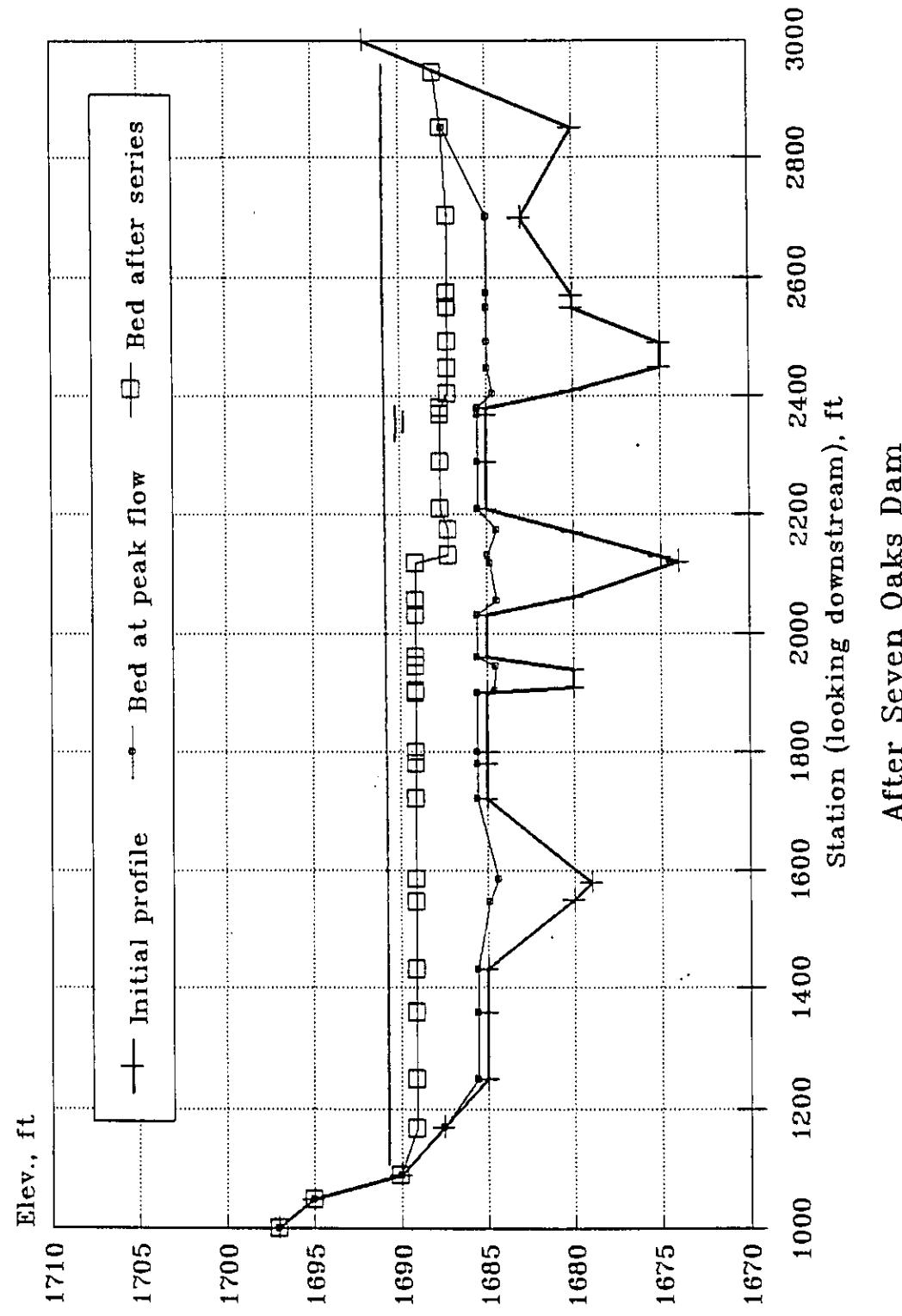
Simulated Changes During Flood Series
at Sec. 38.11



Simulated Changes During Flood Series
at Sec. 38.17

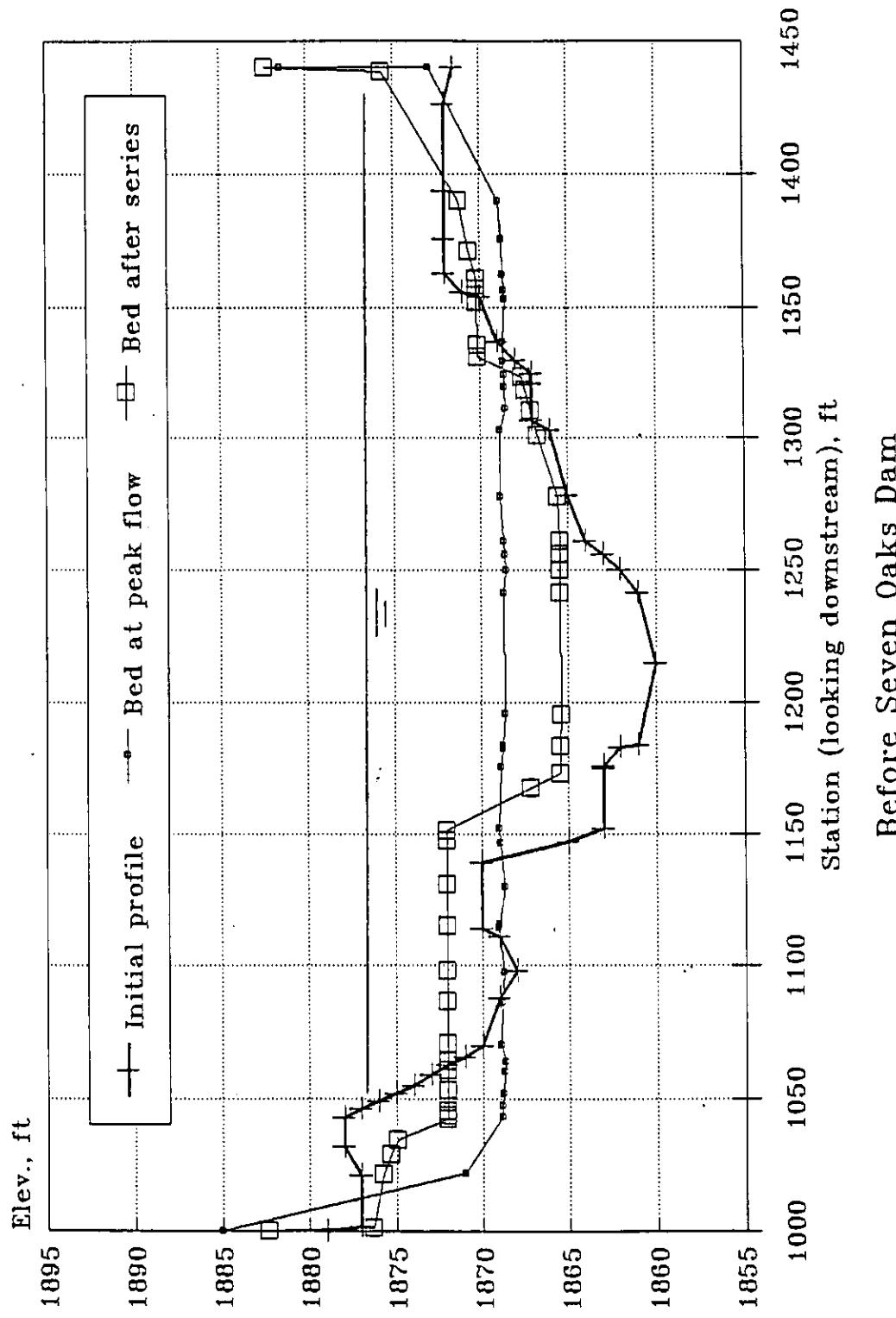


Simulated Changes During Flood Series
at Sec. 38.17



After Seven Oaks Dam

Simulated Changes During Flood Series
at Sec. 39.35



Simulated Changes During Flood Series
at Sec. 39.35

